In evaluating the usefulness of Web sites, a student researcher may want to consider the following questions:

1. **Who owns the site?**
   - .edu: sponsored by educational institutions, especially colleges and universities. Typically carries acceptable and scholarly information. A tilde (~) in the address may signify a personal Web page.
   - .gov: owned by the U.S. government. Typically used to highlight information printed in brochures and pamphlets. Information found here is generally reliable.
   - .org: owned by an organization—not necessarily a nonprofit. Can be good sources of information, but may carry an agenda.
   - .mil: owned by a branch of the U.S. Military.
   - .com: commercial Web sites that are maintained by a company. May be reliable, but not necessarily scholarly.
   - .net: first used for administrative purposes, now available for anyone. Wide variety of owners, and not necessarily scholarly.
   - .biz: business Web sites that are available to anyone. May be reliable, but not necessarily scholarly.
2. **Who are the authors of the site and why did they write it?** What are the author's credentials? What qualifies the individual(s) to comment on this topic? Are they trying to provide information (perhaps the result of their research), promote their point of view, or sell something?
3. **What is the format of the information?** Is it a journal article, popular magazine, newspaper report? Academic journal articles are generally peer-reviewed and the author's research methods and conclusions assessed before publication.
4. **Does the author provide other references that help support his/her research or conclusions?**
5. **When was the site last revised?**
6. **Can the information from this site also be found at another site?** The ability to "get the same answer twice" via Internet searching is a good way to check information.

Other evaluation criteria that you have developed:

Healthy Water, Healthy People Profile

To develop your own ***Healthy Water, Healthy People Profile,*** conduct Internet research to complete the following tasks:

1. Go to the United States Environmental Protection Agency's "Surf Your Watershed" Web Site at http://www.epa.gov/surf. Locate your watershed using any of the several methods offered on this page (e.g., zip code, city, county, etc.). Find the name of your watershed and record it. Then click on the "Index of Watershed Indicators" from that page and record the score from the scale on the right of that page.

2. Find the drinking water quality report issued by each city's drinking water treatment facility. If your city's report is not available on the Web, look for one from larger cities nearby. Within the report, there will be an abbreviation of "MCL." Record the meaning of the abbreviation. If your city's report is not readily available through an Internet search, try visiting http://www.epa.gov/safewater/dwinfo.htm and click on your state.

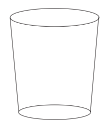
3. Conduct a search to generate a listing of water quality issues in your state (e.g., search for "your state + water quality issues"). Choose an issue and record the different Web sites that are related to it. From a reliable source, summarize the issue in a short paragraph. Note if you found any "unreliable" sources of information related to this issue and why you feel it is unreliable.

Making Mixtures

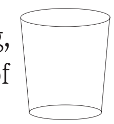
1. You should have five cups, each half-full of water and each labeled individually "a" through "e". Prepare the following mixtures in these cups, drying the spoon with the paper towel between each mixture:

a) Add 1 teaspoon of salt to the cup labeled "a" and stir until the salt dissolves. (Don't forget to dry the spoon after stirring!)

Immediately after stirring, record any observations of your mixture in this cup:

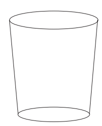


Five minutes after stirring, record any observations of your mixture in this cup:

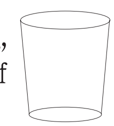


b) Add 2 drops of milk to the cup labeled "b" and stir vigorously.

Immediately after stirring, record any observations of your mixture in this cup:

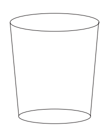


Five minutes after stirring, record any observations of your mixture in this cup:

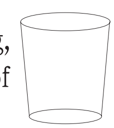


c) Add 1 teaspoon of glitter to the cup labeled "c" and stir vigorously.

Immediately after stirring, record any observations of your mixture in this cup:

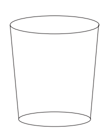


Five minutes after stirring, record any observations of your mixture in this cup:

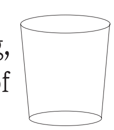


d) Add 1 tablespoon of oil to the cup labeled "d" and stir vigorously.

Immediately after stirring, record any observations of your mixture in this cup:



Five minutes after stirring, record any observations of your mixture in this cup:



e) Add NOTHING to the cup labeled "e".

2. Read the definitions below and use them to fill in the chart on the following page. You may also wish to use the Tyndall effect to determine which mixture is a colloid. To do this, pour the mixture you want to check into a glass jar and place it over one of the small holes in the paper on the overhead projector (or laser pointer/flashlight).

Making Mixtures (continued)

Solvent: dissolving agent in a solution, usually the component present in the larger quantity.

Solute: dissolved substance in a solution, usually the component present in the smaller quantity.
Example: When sugar is dissolved in tea, the tea is the solvent and the sugar is the solute.

Homogeneous mixture: a mixture that is uniform or the same throughout.
Example: Sports drink from a carton. Each glass poured is the same as the last.

Heterogeneous mixture: a mixture that is not uniform throughout.
Example: Orange juice with lots of pulp, especially when not shaken. The first few glasses poured would contain less pulp than the last few glasses.

An **emulsion** is a mixture of two liquids that will separate after standing. Which of the above mixtures is an emulsion?

A **colloid** is a mixture containing solid particles that are small enough to remain suspended yet large enough to reflect light. Which of the above mixtures is a colloid?

A **suspension** is a mixture containing large, dispersed solid particles that can settle out and be separated by filtration. Which of the above mixtures is a suspension?

A **solution** is a homogeneous mixture that forms when one substance dissolves another. Which of the above mixtures is a solution? In the solution, what is the solute and what is the solvent? Under each letter, use the terms above to describe the type of mixture and whether each is homogenous or heteroenous.

	A	B	C	D	E
Type of Mixture					
Heterogeneous or Homogeneous					

3. **Of the above mixtures, two are actually solutions. Since gases (such as oxygen) and minerals (such as calcium) are naturally dissolved in water, even tap water is a solution. Set all samples but the two solutions aside. One of the group members must shuffle the two solutions while the rest of the group covers their eyes.**

Since both solutions are clear, how can they be distinguished from one another? Remember, NEVER TASTE CHEMICAL SOLUTIONS! Without tasting the two solutions, brainstorm ways to determine which is salt water and which is tap water.

Data Sheet

I. After adding a common household item to the cabbage water, stir briefly and record your findings in the following table.

Common Household Item		Color of Solution
Cabbage water, nothing added		
Sample #1	15 drops (1ml) of cola added	
Sample #2	15 drops (1ml) of lemon juice added	
Sample #3	A ½ teaspoon (1.3 g) of baking soda added	
Sample #4	15 drops (1 ml) of ammonia added	

II. Look at the color change of the samples in Part I and determine whether the color change indicates the solution is an acid, a base, or neutral. Discuss with your group where on the scale you think each sample belongs. For example, the pH of purple cabbage water with nothing added is 7. Write "purple cabbage water" under the neutral (7) on the scale. Write the sample number on the scale where you think each sample belongs according to their pH.

Acid **Neutral** **Base**

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

III. After completing the experiment, answer the following questions.

1. What makes the cabbage water change color upon adding lemon juice?

2. What makes the cabbage water change color upon adding ammonia?

3. What do you think would happen if you combined the lemon juice solution with the ammonia solution?

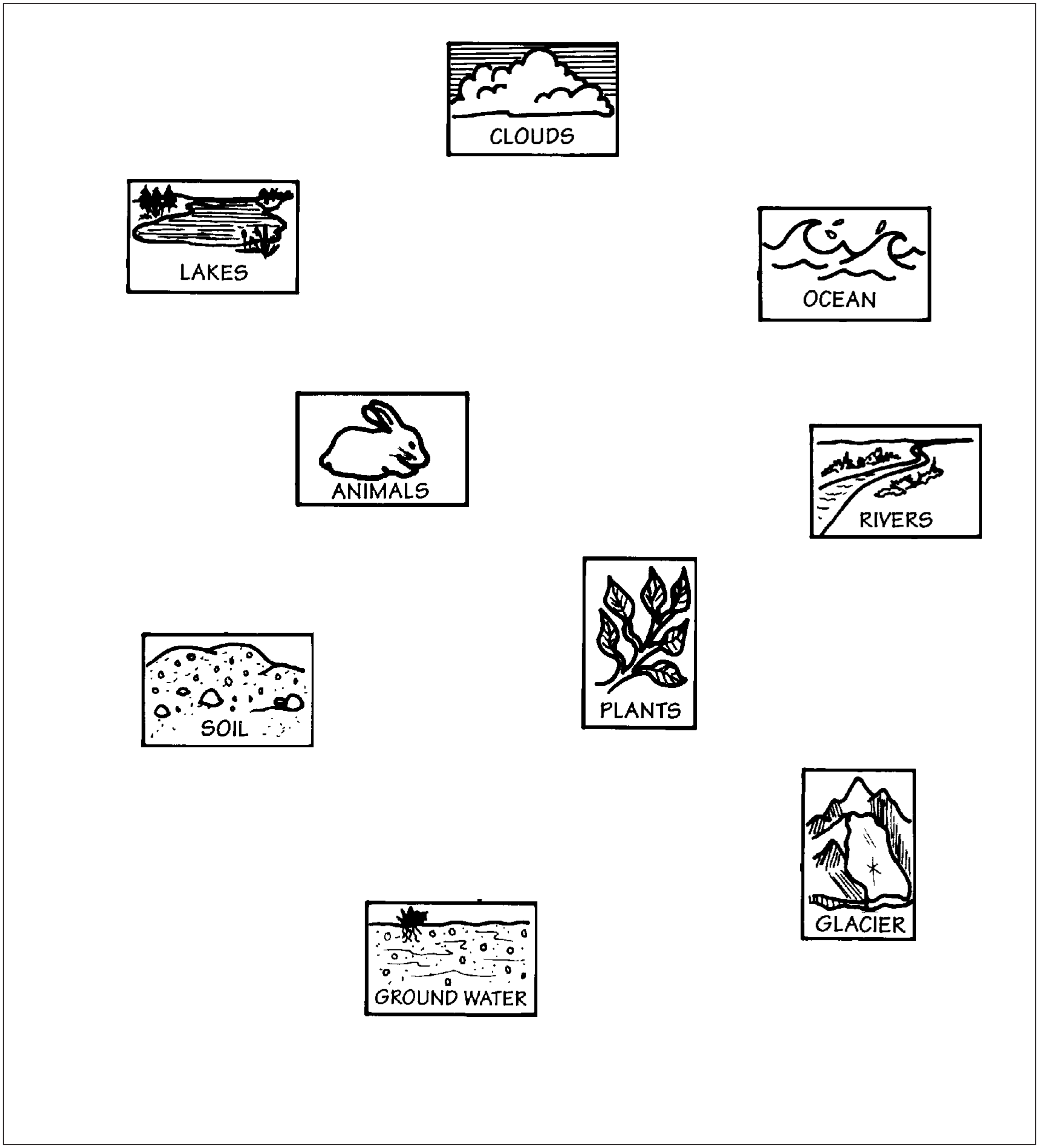
Water Pollution Chart

Water Cycle Station	Water Quality Benefits and Impacts
If students move to…	Station Monitors instruct students to collect or remove pollution according to the following chart…
Soil	From Clouds–collect 1 for airborne contaminants From Animal–collect 2 for wastes
Plants	From Soil–remove 1 as some plants absorb pollutants from water.
River	From Soil–collect 2 for sediment from erosion From Lake–neither collect nor remove any tokens From Ground Water–remove 1 as ground water often is filtered by soil before it enters ground water aquifers
Clouds	From All Stations–remove 2 as water is purified as it evaporates
Ocean	From Clouds–collect 1 for airborne pollutants brought down with rain From River–collect 2 for pollutants carried in the river
Lake	From River–collect 2 for pollutants carried in the river From Clouds–collect 1 for airborne pollutants brought down with rain From Ground Water–remove 1 as ground water often is filtered by soil before it enters ground water aquifers
Animals	From Lake–neither collect or remove pollutants From River–neither collect or remove pollutants
Ground Water	From Soil–remove 1 as soil is a filter for pollutants From Lake–remove 1 as it moves through soil first, which filters pollutants From River–remove 1 as it moves through soil first, which filters pollutants From Glacier–remove 1 as it moves through soil first, which filters pollutants
Glacier	From All Stations–remove 2 as pollution is removed as water freezes

Water Cycle Table

STATION	DIE SIDE LABELS	EXPLANATION
Animal	two sides *soil* three sides *clouds* one side *stay*	Water is excreted through feces and urine. Water is respired or evaporated from the body. Water is incorporated into the body.
Clouds	one side *soil* one side *glacier* one side *lake* two sides *ocean* one side *stay*	Water condenses and falls on soil. Water condenses and falls as snow onto a glacier. Water condenses and falls into a lake. Water condenses and falls into the ocean. Water remains as a water droplet clinging to a dust particle.
Glacier	one side *ground water* one side *clouds* one side *river* three sides *stay*	Ice melts and water filters into the ground. Ice evaporates and water goes to the clouds (sublimation). Ice melts and water flows into a river. Ice stays frozen in the glacier.
Ground Water	one side *river* two sides *lake* three sides *stay*	Water filters into a river. Water filters into a lake. Water stays underground.
Lake	one side *ground water* one side *animal* one side *river* one side *clouds* two sides *stay*	Water is pulled by gravity; it filters into the soil. An animal drinks water. Water flows into a river. Heat energy is added to the water; water evaporates and goes to the clouds. Water remains within the lake or estuary.
Ocean	two sides *clouds* four sides *stay*	Heat energy is added to the water; water evaporates and goes to the clouds. Water remains in the ocean.
Plant	four sides *clouds* two sides *stay*	Water leaves the plant through the process of transpiration. Water is used by the plant and stays in the cells.
River	one side *lake* one side *ground water* one side *ocean* one side *animal* one side *clouds* one side *stay*	Water flows into a lake. Water is pulled by gravity; it filters into the soil. Water flows into the ocean. An animal drinks water. Heat energy is added to the water; water evaporates and goes to the clouds. Water remains in the current of the river.
Soil	one side *plant* one side *river* one side *ground water* two sides *clouds* one side *stay*	Plant roots absorb water. The soil is saturated, so water runs off into a river. Water is pulled by gravity, and filters into the soil. Heat energy is added to the water; water evaporates and goes to the clouds. Water remains on the surface (in a puddle or adhering to a soil particle).

Water Journey Map



Water Quality Measurement Worksheet

Part I

1. Predict the weights of several objects found in the classroom:

Part II

1. Drop a one-gram object into your liter of water. What measurement or concentration results?

2. The instructor distributed tiny specks of paper and each was said to represent one thousandth of a gram. What is another way to refer to this measurement?

3. Drop one of the specks into your liter of water. What measurement or concentration results?

Part III

1. The 1 kg of substance before you contains one million grains.

2. Grab one grain of the substance. How many parts per million (ppm) of the substance do you hold?

3. Drop the grain into your liter of water. What concentration of the substance results from this? (Hint: You can express it two ways—as ppm or as mg/L.)

4. To convert parts per million (ppm) to parts per billion (ppb), grab another grain of substance. Imagine this grain of substance sliced into 1000 pieces.

5. Using a pen, touch the ink to a piece of paper to get the tiniest speck possible. Have a contest between the members of your group to see who can make the tiniest speck. Let this speck represent one microgram (even though a microgram is actually much smaller than this speck), which is 1000 times smaller than a milligram.

   Speck ________________________________

6. One microgram per liter is equal to one part per billion (ppb). Some contaminants (e.g., arsenic) present health risks in such small amounts that they are often measured in parts per billion.

Comparison of International Drinking Water Guidelines

Refer to the *Comparison of International Drinking Water Guidelines* chart and answer the questions below:

1. Is 1 mg/L an acceptable level of:
    a. Arsenic in the U.S. according to the Environmental Protection Agency? ____________________
    b. Arsenic according to the World Health Organization (WHO)?____________________
    c. Copper in the U.S. according to the Environmental Protection Agency?____________________

2. Add grains of substance until you have a mixture of 11 mg/L. Is this an acceptable level of:
    a. Sulfate in Canada?____________________
    b. Nitrates in U.S.?____________________
    c. Nitrates in Canada?____________________

Comparison of International Drinking Water Guidelines

Contaminant	USEPA	Canada	World Health Organization	Potential Health Effects	Sources of Contamination
Arsenic	0.05* mg/L (50 ppb)	0.025 mg/L (25 ppb)	0.01 mg/L (10 ppb)	Skin damage; circulatory system problems, risk of cancer	Erosion of natural deposits; runoff from glass and electronics production wastes
Copper	1.3 mg/L	1.0 mg/L	1-2 mg/L	Short term exposure: gastrointestinal distress. Long term exposure: Liver-kidney damage	Corrosion of household plumbing systems; erosion of natural deposits
Nitrates	10.0 mg/L as N	10.0 mg/L as N	50 mg/L as NO_3	"Blue Baby Syndrome": In infants under six months—life threatening without immediate medical attention	Runoff from fertilizer use: Leaching from septic tanks or sewage; erosion of natural deposits
Sulfate	250 mg/L	500 mg/L	250 mg/L	Gastrointestinal effects	Burning fossil fuels leads to atmospheric deposition

Adapted from: *Water Analysis Handbook.* Hach Company. Used with permission. * On February 22, 2002 the USEPA established the arsenic in drinking water rule, lowering the arsenic MCL to 10 ppb; the date by which drinking water treatment systems must comply with the new 10 ppb standard is January 23, 2006.

Part I: Marbles

First Trial:
In fifteen seconds, the red and blue marbles touched ______________ times.

Second Trial:
In fifteen seconds, the red and blue marbles touched ______________ times.

Wrap Up:
List possible reasons that the first and second trials were different:

What affect did the white, buffering marbles have on the water (blue marbles)?

In which trial was the water the least acidic?

Part II: Tape

First Trial:
In fifteen seconds, the number of pieces of red tape that the acidity student placed on the water is ______________ pieces.

Second Trial:
In fifteen seconds, the number of pieces of red tape that the acidity student placed on the water is ______________ pieces.

Wrap Up:
List possible reasons that the first and second trials were different:

What affect did the alkalinity students have on the water?

In which trial was the water the least acidic, or of lowest pH?

What role does alkalinity play in water?

Designing Your Own Experiment

Refer to the steps of the scientific method as you design your own experiment using some or all of the materials given to your group. An example of a simple experiment that follows the scientific method is given. Fill in the blank chart below to help you design and conduct your experiment.

Steps of the Scientific Method	Example
Observation *Identification of problem or question*	The two sides of a coin are different. Water drops can accumulate on the side of a coin without spilling. The tails side has smaller images.
Hypothesis *A prediction of the expected result*	The tails side of a coin will hold more drops of water than the heads.
Procedure *How you will test hypothesis*	Drop individual drops of water from a vertically-held eyedropper, one inch above the coin, onto both sides until they spill over. Repeat 3x per side. Count the drops and average each side.
Data Collection and Analysis *Take detailed notes of your observations*	Conduct the test according to the procedures. The tails side holds more drops.
Conclusions *Never **prove** a hypothesis—confirm or deny a hypothesis*	Confirm/accept the hypothesis as the tails side of the coin held more water drops than the heads side.

Complete this chart to help you design your own experiment:

Steps of the Scientific Method	Your Experiment
Observation Identification of problem or question	
Hypothesis A prediction of the expected result	
Procedure How you will test hypothesis	
Data Collection and Analysis Take detailed notes of your observations	
Conclusions Never **prove** a hypothesis—confirm or deny a hypothesis	

Healthy Water, Healthy People Science Fair Projects

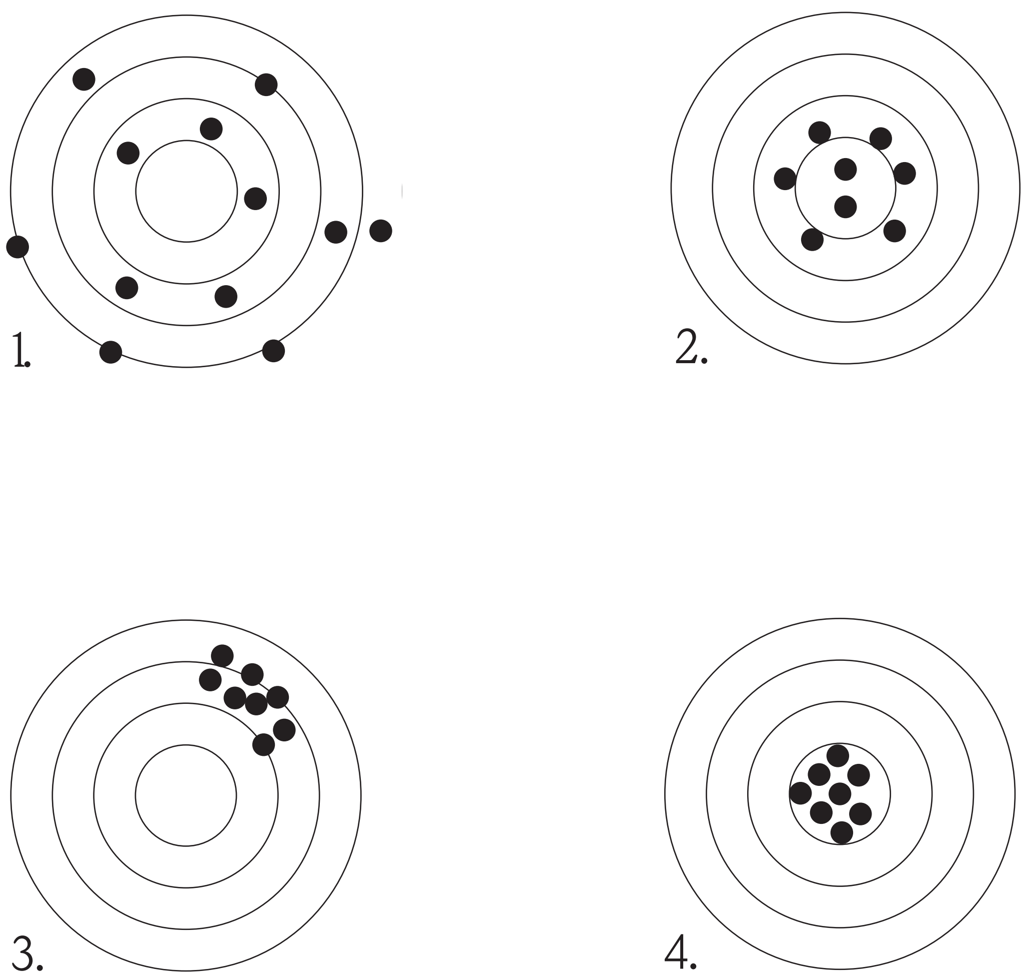
The Healthy Water, Healthy People materials are ideal for use with science projects. Below is a sample of possible science project ideas using these materials. At the bottom of the list, fill in your own science project ideas.

General Topics:

- Why does the (dissolved oxygen/pH/nitrate/phosphate/flow/turbidity/conductivity/etc.) change from one part of my watershed to another?
- What are the differences in water quality between a local stream and pond/lake, and why?
- What is the pH of the rain or snow that falls near my school? Is it different depending on the location, weather pattern, or season?
- What do the macroinvertebrates found in a local river tell me about its water quality?
- Which type of water treatment/filter works the best for removing different contaminants?
- Is my well water/tap water safe to drink?
- How can I design a simple water treatment system for my home/cattle/fish tank?
- How does the geology of my area affect the water quality of the local streams and lakes? (alkalinity/pH/turbidity)
- What types of contaminants are found in runoff water from local parks/neighborhoods/ highways/other?
- What is the best method for keeping eroding sediments out of a stream?
- Which is the difference in pH/salinity/conductivity of soils from a wetland/pasture/ forest/playground/park/ garden/etc. and why? What affect does this have on plants?
- Why does the dissolved oxygen content differ between water bodies, seasonally, and at different times of the day? How does this affect aquatic organisms?
- Which nutrient (nitrate or phosphate) travels through the soil and which is held there? How does this affect the water quality of wells?
- How does the pH of soil differ between sites that are under pine trees and those that are not and why?
- How does sediment enter a waterway and what affect does it have on the temperature and dissolved oxygen of that water?
- Which type of soap is most effective at killing bacteria on your hands?
- What ecological and water quality changes occur when different restoration practices are conducted in a stream (vegetation planted on banks, logs sunken in stream, pollution removed, etc.)?

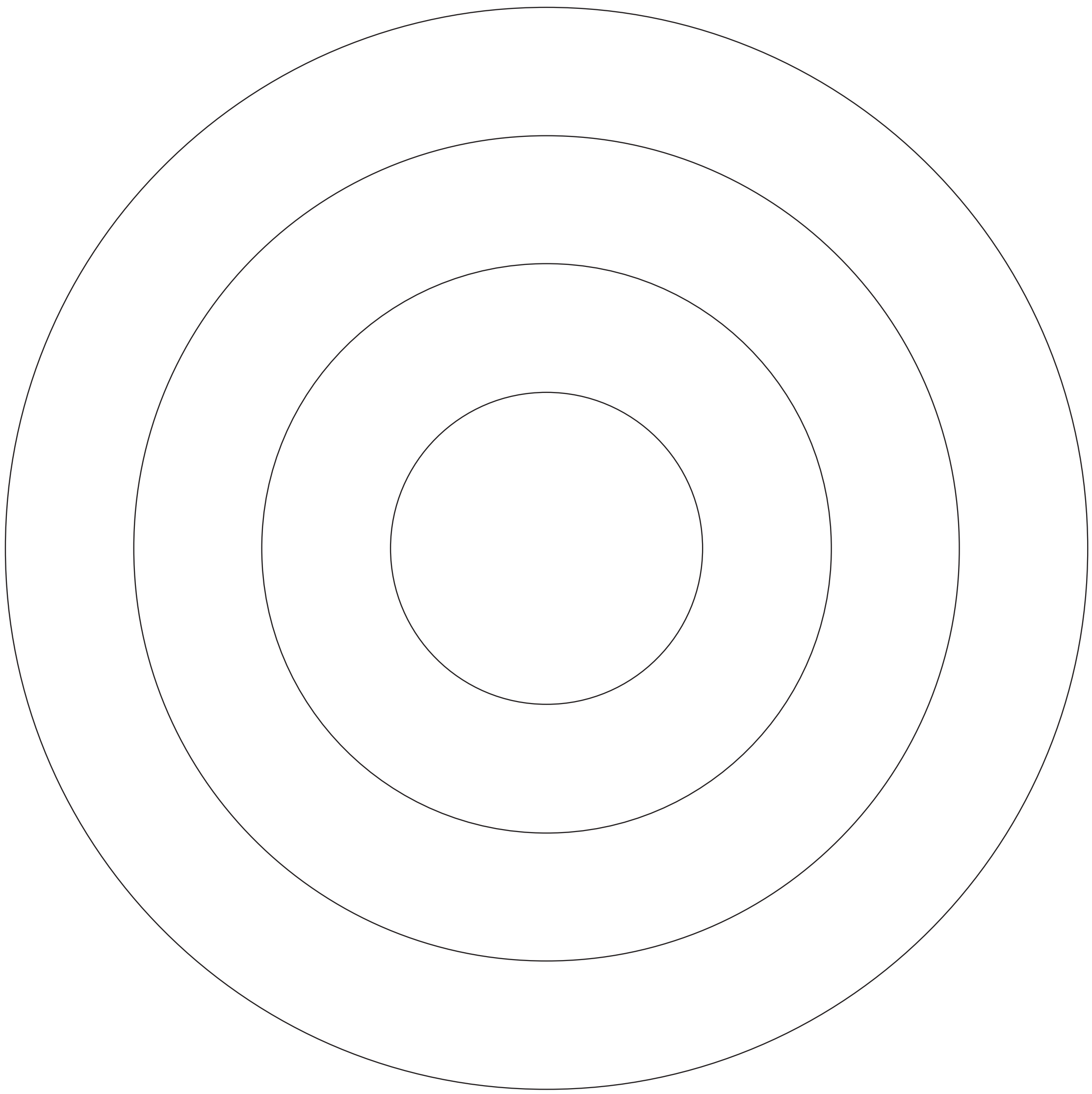
List Your Science Project Ideas Below:

Accuracy and Precision Illustrations



Adapted from *Water Analysis Handbook*. Hach Company: Loveland, CO. Used with permission.

Target



WebQuest Perspectives

Polly/Paul E. Tishen, **City Manager** · http://wow.nrri.umn.edu/wow/under/parameters/turbidity.html	Chip Silica, **Microchip Plant Owner** · www.hach.com/h2ou/h2wtrqual.htm#turbidity
Connie Sumer, **Consumer and Concerned Mother** · http://wow.nrri.umn.edu/wow/under/parameters/turbidity.html · http://cru.cahe.wsu.edu/CEPublications/eb0994/eb0994.html	Joan/John Dear, **Farmer and Nursery Owner** · www.verde.org/divert/wp319.html
E.P. Agenson, **Environmental Regulator** · www.epa.gov/safewater/mdbp/pdf/turbidity/chap_09.pdf	Dr. Samantha Gold, **Scientist** · www.fao.org/DOCREP/MEETING/003/YO174E.HTM#P353-25299
Tom Driven, **Highway Department** · http://www.nmenv.state.nm.us/swqb/cordovaTMDL.html	Eddy Sanford, **Forester** · www.forestry.state.ar.us/bmp/roads.html
George Fly, **Fisherman** · www.combat-fishing.com/streamecology.html	Mary Brown, **Treatment Plant** · www.dep.state.pa.us/ra-epprintshop@state.pa.us

WebQuest Student Worksheet

Using the Internet links provided, research the turbidity issue from the point of view on your WebQuest Perspectives Card by reading the background and completing the following questions:

Background:

Cooper Township is a small community (population 25,000) that is supported by several businesses, including construction firms for the growing community, farms, a small Microchip Production Plant, and local tourist services—fishing tackle shops, historical tour guides, craft shops, hotels, restaurants, and antique stores. Cooper Township has a large stream running through it and this stream supplies the township's drinking water. The watershed for the stream is entirely contained within the township, and the stream typically carries a heavy sediment load and is high in turbidity. The Cooper Township Council has called a town meeting to discuss the issue of high turbidity in the stream and the town's drinking water and what to do about it.

Your Task:

Research the issue of high turbidity in the local stream from the perspective on your WebQuest Perspectives Card using the Internet links provided. You may also use local resources, experts, and other resources as needed. At the end of the activity, your group will be asked to present your point of view of the high turbidity issue and to be able to defend your point of view in a public meeting. You will also be asked what your group recommends should be done to reduce the high turbidity levels in the stream.

Research Questions to Answer:

1. List whom you represent and any background information about your perspective from the Web Quest Perspectives Card.

2. Make a list of all the resources you used to research your perspective, including Internet sites, local resources, etc.

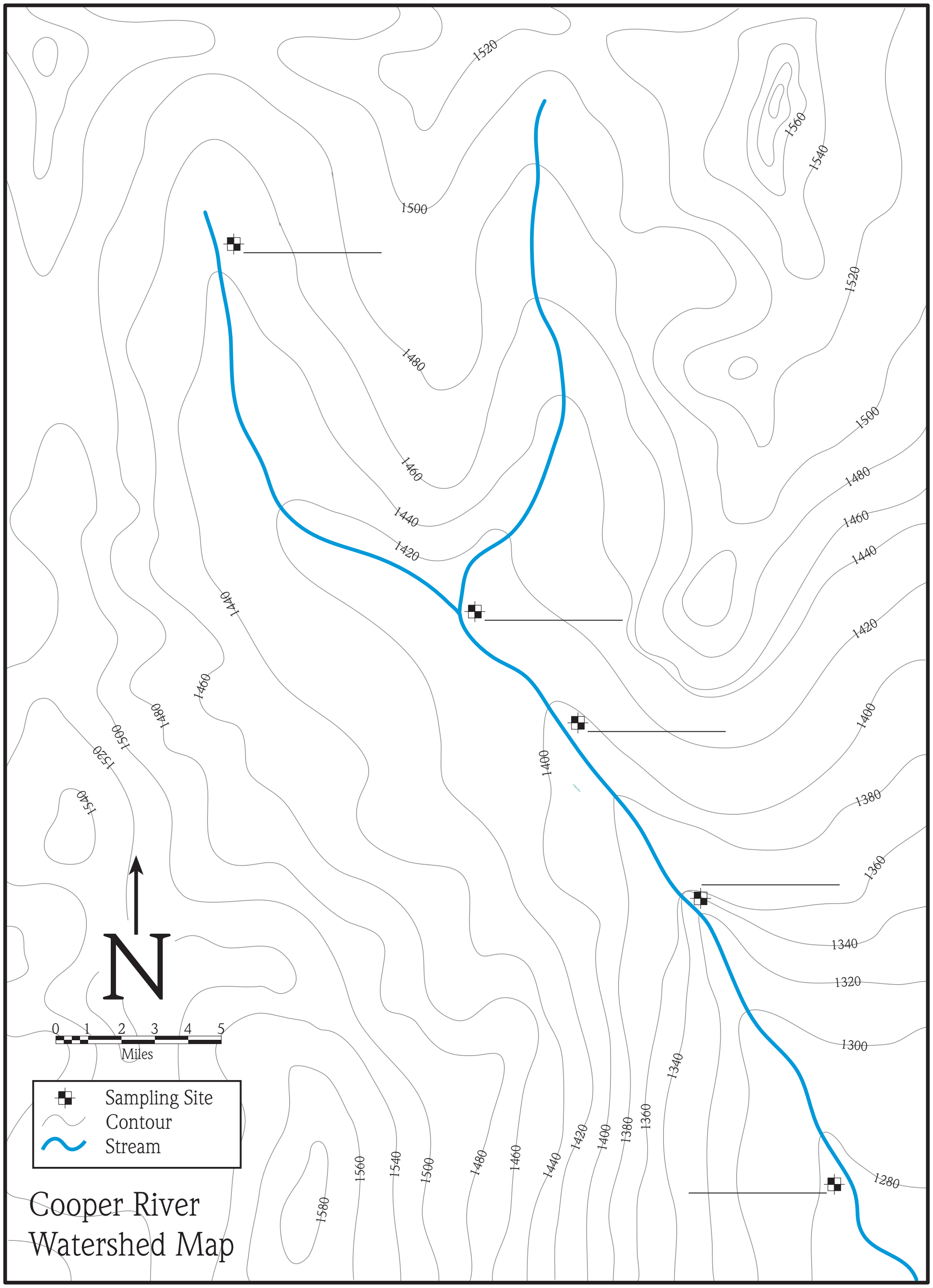
3. How strongly do you care about the high turbidity in the stream? Are you strongly opposed to it, moderately opposed to it, don't care, or support the high turbidity? Provide evidence to support your position.

4. What do you think should be done about the issue of high turbidity in the town's drinking water?

Presenting Your Point of View:

You will present your point of view in a town meeting in front of the mayor and city council members. Be prepared to give a professional presentation of your perspective (visual aids are recommended). Support your point of view with evidence you found in your research.

Cooper River Watershed Map



Cooper River Water Data Cards

Headwaters: Date: January 5 Conditions: River is partially frozen; clear day. Temp: .5° C DO: 14.5 mg/L Clarity: 48 cm Flow: 800 cfs	**Headwaters:** Date: April 7 Conditions: River is at high flows due to spring runoff. Temp: 4.4° C DO: 14.5 mg/L Clarity: 6 cm Flow: 2000 cfs	**Headwaters:** Date: July 6 Conditions: Hot and humid, but the trees over the river offer shade. Temp: 12.8° C DO: 12mg/L Clarity: 26 cm Flow: 1200 cfs	**Headwaters:** Date: October 9 Conditions: Cool, fall day; leaves falling in the water. Temp: 10° C DO: 13 mg/L Clarity: 33 cm Flow: 750 cfs
Confluence: Date: January 5 Conditions: The combined flows keep the river free of ice. Temp: .5° C DO: 14.5 mg/L Clarity: 46 cm Flow: 1600 cfs	**Confluence:** Date: April 7 Conditions: Spring rains have led to high runoff. Temp: 4.4° C DO: 14.5 mg/L Clarity: 5 cm Flow: 4000 cfs	**Confluence:** Date: July 6 Conditions: Much of the bank is showing due to low flows. Temp: 11.7° C DO: 11.5 mg/L Clarity: 20 cm Flow: 2000 cfs	**Confluence:** Date: October 9 Conditions: Cool temperatures; leaves are changing colors. Temp: 9.4° C DO: 12 mg/L Clarity: 32 cm Flow: 1500 cfs
Midriver: Date: January 5 Conditions: Small ice sheets float by as you conduct your sampling. Temp: 1.7° C DO: 12 mg/L Clarity: 42 cm Flow: 1600 cfs	**Midriver:** Date: April 7 Conditions: Sediment levels are high due to the high flows. Temp: 7.2° C DO: 13 mg/L Clarity: 8 cm Flow: 4000 cfs	**Midriver:** Date: July 6 Conditions: Algae is beginning to grow along the edges of the river. Temp: 16° C DO: 8 mg/L Clarity: 17 cm Flow: 2000 cfs	**Midriver:** Date: October 9 Conditions: The water feels cool to the touch as fall approaches. Temp: 11° C DO: 9 mg/L Clarity: 24 cm Flow: 1500 cfs

Cooper River Water Data Cards

Falls: Date: January 5 Conditions: The churning water at the falls keeps ice from forming on the river. Temp: 2.8° C DO: 13 mg/L Clarity: 32 cm Flow: 1600 cfs	**Falls:** Date: April 7 Conditions: High flows have almost washed out the falls. Temp: 8.9° C DO: 12.2 mg/L Clarity: 8 cm Flow: 4000 cfs	**Falls:** Date: July 6 Conditions: Swimmers frequent the pool below the falls in summer. Temp: 18.3° C DO: 9 mg/L Clarity: 11 cm Flow: 2000 cfs	**Falls:** Date: October 9 Conditions: Low autumn flows greatly reduce the size of the falls. Temp: 12.8° C DO: 10 mg/L Clarity: 18 cm Flow: 1500 cfs
Downriver: Date: January 5 Conditions: Winter winds blow strong, keeping the river free of ice. Temp: 3.3° C DO: 6 mg/L Clarity: 32 cm Flow: 1600 cfs	**Downriver:** Date: April 7 Conditions: Brown, turbid water from high flows. Temp: 10° C DO: 7 mg/L Clarity: 8 cm Flow: 4000 cfs	**Downriver:** Date: July 6 Conditions: Dark, deep, and warm water slowly passes by your site. Temp: 22.8° C DO: 3 mg/L Clarity: 11 cm Flow: 2000 cfs	**Downriver:** Date: October 9 Conditions: The water seems clearer now than in the summer. Temp: 15° C DO: 4 mg/L Clarity: 18 cm Flow: 1500 cfs

Watershed Data Summaries Worksheet

Single Sample
Sampling Site
Seasons
Project Summary

Table Monitoring Goals

Group 1 Monitoring Goal: Interested in tracking the changes in the amounts of all liquids. **What you will monitor:**	**Group 2** Monitoring Goal: Interested in tracking changes in objects that are taller than 5 cm. **What you will monitor:**
Group 3 Monitoring Goal: Interested in tracking changes in the size and location of writing implements. **What you will monitor:**	**Group 4** Monitoring Goal: Interested in tracking changes in objects that are primarily blue, red, and green. **What you will monitor:**
Group 5 Monitoring Goal: Interested in tracking changes in objects that are primarily white, black, and grey. **What you will monitor:**	**Group 6** Monitoring Goal: Interested in tracking changes in objects that are greater than 50 cm^2 in size. **What you will monitor:**

Table Monitoring Worksheet

1. Monitoring Goal (from monitoring goal card):

2. What parameters you will monitor (from monitoring goal card):

3. Data Collection: Baseline Data–Draw or note the objects you are monitoring as they exist in their original state or position.

After 5 minutes–Draw or note what you observe about the objects you are monitoring.

After 10 minutes–Draw or note what you observe about the objects you are monitoring.

4. Data Analysis and Findings:
   - What changes did you notice?
   - What trends did you observe in your data? (e.g., was there less coffee in the mug each time?)
   - What parameters stayed the same over the monitoring period?

Watershed Trends Worksheet

Refer to the ***Gallatin Watershed Overview*** and ***Gallatin Watershed Data Set*** to complete the following study design:

1. Monitoring Purpose:

2. Parameters to be monitored (see ***Gallatin Watershed Data Set***):

3. Data Quality Objectives:

4. How monitoring will be conducted:

5. Where monitoring will be conducted:

6. When monitoring will be conducted:

7. Who will conduct monitoring:

8. Quality Assurance Measures:

9. Data Analysis: Develop Findings about the Data:
   a. Graph the data for your parameter. *{See examples @ www.healthywater.org}*
      I. What trends do you observe?
      II. Do results change upstream to downstream?
      III. Where in the watershed did you notice changes in data?
   b. Develop conclusions based on your findings about the data?
      a.
      b.
      c.
   c. Develop recommendations (e.g., no action, ways to reduce pollution, further monitoring, etc.):
      a.
      b.
      c.

Gallatin Watershed Data Set

Dates	Streams	pH	Water Temp (°C)	Turbidity (FTU)	Nitrate (mg/L)	D.O. (mg/L)	Percent Saturation
7-29-00	Park Boundary	8.3	8.0	——	0.02	10	85
	Upstream	8.1	11.0	——	0.05	8	80
	West Fork	8.4	10.0	——	0.04	10	90
	Downstream 1	7.4	11.0	——	0.04	9	82
	Dudley Cr.	7.7	6.5	——	0.06	11	90
	Downstream 2	8.6	12.5	——	0.03	10	100
9-9-00	Park Boundary	8.3	2.0	——	0.03	10.5	74
	Upstream	7.8	8.0	——	0.075	5	44
	West Fork	8.6	4.0	——	0.035	9.5	72
	Downstream 1	8.1	7.0	——	0.05	8	66
	Dudley Cr.	8.0	3.5	——	0.01	10	74
	Downstream 2	8.6	8.0	——	0.025	10	85
10-22-00	Park Boundary	7.5	1.0	——	0.045	9.5	67.5
	Upstream	7.9	0.0	——	0.04	9	62
	West Fork	7.6	-4.0	——	0.06	10.5	66.5
	Downstream 1	7.9	5.0	——	0.05	9	70
	Dudley Cr.	8.0	-2.0	——	0.04	11	73
	Downstream 2	8.6	1.0	——	0.03	10.5	72.5
12-2-00	Park Boundary	7.7	0.0	——	0.085	2.3	15
	Upstream	7.1	7.0	——	0.09	2.75	24
	West Fork	7.8	1.0	——	0.19	1.5	11
	Downstream 1	7.8	7.0	——	0.12	1.5	13
	Dudley Cr.	7.8	1.0	——	0.09	7.75	55
	Downstream 2	8.1	4.0	——	0.06	10.25	77
1-13-01	Park Boundary	7.5	-2.0	——	0.085	11	70
	Upstream	7.4	0.0	——	0.075	9	61
	West Fork	7.4	-2.0	——	0.185	11.5	73.5
	Downstream 1	7.5	3.0	——	0.12	9	67
	Dudley Cr.	8.0	-2.0	——	0.05	11.5	73.5
	Downstream 2	8.3	3.0	——	0.075	10	74
3-24-01	Park Boundary	8.0	3.0	——	0.045	12	87
	Upstream	7.8	3.5	——	0.04	11	80
	West Fork	8.3	2.0	——	0.125	12	85
	Downstream 1	8.0	2.5	——	0.055	8.5	61.5
	Dudley Cr.	8.0	4.0	——	0.07	11.5	86
	Downstream 2	8.4	7.0	——	0.025	10	82
4-28-01	Park Boundary	7.6	4.0	——	0.04	11.36	85
	Upstream	7.5	9.0	——		11.4	97
	West Fork	7.2	4.0	——	0.085	11.9	89
	Downstream 1	7.6	5.0	——	0.075	11.4	87
	Dudley Cr.	7.6	7.0	——	0.08	11	90
	Downstream 2		6.6	——		10.2	82

Dates	Streams	pH	Water Temp (°C)	Turbidity (FTU)	Nitrate (mg/L)	D.O. (mg/L)	Percent Saturation
7-14-01	Park Boundary	8.1	10.9	4	0.035	9.5	86
	Taylor Fork	7.9	12.3	7	0.035	10	95
	Upstream	8.3	15.1	7.5	0.035	9.5	95
	West Fork	8.7	13.2	7.5	0.025	10.5	100.5
	Downstream 1	8.5	14.0	6.0	0.035	10.5	102
	Dudley Cr.	8.2	13.1	1.0	0.04	10	96
	Downstream 2	8.5	16.4	6.5	0.03	9.5	99.5
8-12-01	Park Boundary	7.6	8.0	2.5	0.025	11.5	96
	Taylor Fork	8.2	9.0	3.5	0.025	9.5	82.5
	Upstream	8.0	13.0	0.0	0.03	9.5	91.5
	West Fork	8.4	12.2	2.5	0.03	10	95
	Downstream 1	8.4	13.9	1.0	0.045	9	88.5
	Dudley Cr.	8.3	12.2	1.5	0.05	9.5	89.5
	Downstream 2	8.6	15.5	2.0	0.03	9.5	96
9-15-01	Park Boundary	8.0	5.3	0.5	0.03	12	93
	Taylor Fork	8.4	6.7	0.5	0.02	10	80
	Upstream	7.2	10.0	1.5	0.04	9.5	84.5
	West Fork	8.5	8.2	3.0	0.05	10.5	88
	Downstream 1	8.3	10.9	1.5	0.06	9	82
	Dudley Cr.	7.9	8.8	0.5	0.045	10	85
	Downstream 2	8.6	12.5	0.5	0.03	9.5	90
10-13-01	Park Boundary	7.1	0.0	0.0	0.05	12.5	83.5
	Taylor Fork	7.2	1.0	0.5	0.05	12	83
	Upstream	7.3	2.8	1.0	0.04	12	85
	West Fork	8.0	1.4	1.5	0.1	12.5	84.5
	Downstream 1	8.0	4.7	0.0	0.06	11	85
	Dudley Cr.	7.9	2.4	0.5	0.055	12	85
	Downstream 2	8.2	5.8	1.0	0.04	11.5	90.5
11-10-01	Park Boundary	7.2	0.2	2.0	0.065	12.5	83.5
	Taylor Fork	7.5	0.0	1.5	0.05	13	85
	Upstream	7.8	1.8	3.0	0.05	8	57.5
	West Fork	8.0	0.1	2.5	0.165	13	87
	Downstream 1	7.8	6.3	2.0	0.12	9.5	77
	Dudley Cr.	7.8	0.7	1.5	0.1	12	80
	Downstream 2	8.1	5.0	1.5	0.05	13.5	102
12-8-01	Park Boundary	7.4	-0.3	1.0	0.11	14	90
	Taylor Fork	7.8	2.4	1.25	0.08	13.75	96
	Upstream	7.4	2.9	1.5	0.1	11	80
	West Fork	7.7	-0.4	1.5	0.26	12	79
	South Fork	8.0	-0.2	3.0	0.145	12	79
	Downstream 1	7.8	4.5	0.5	0.155	10	78
	Dudley Cr.	7.8	0.2	0.0	0.11	12	80
	Downstream 2	8.2	3.8	1.5	0.08	12	89

Gallatin Watershed Overview

Vital Statistics:

From its headwaters in Yellowstone National Park, located in southwest Montana, the Gallatin River flows northward through the Gallatin Canyon to Three Forks, Montana, where it joins the Madison and Jefferson Rivers to form the headwaters of the Missouri River. The river was named by the Lewis and Clark Expedition on July 25, 1805, after President Thomas Jefferson's Secretary of the Treasury Albert Gallatin. Along its length, the Gallatin River flows swiftly through Yellowstone National Park and US Forest Service Land before entering the predominantly private agricultural and urban landscape of the Gallatin Valley. The land immediately adjacent to the river and along Montana Highway 191 is private and used for residential homes, guest ranches, agriculture, ranching, and various tourist-related businesses including motels, restaurants, and gas stations. There is a large ski resort at the upper end of the West Fork, along with a community of residents and numerous ski and tourist-related businesses and accommodations.

Famous for its blue ribbon trout fishery and frequented by anglers from around the world, the river also accommodates rafters, hikers, campers, and sightseers on a year-round basis. In addition to the people that frequent this natural resource, the river corridor also provides habitat for a wide variety of wildlife: bear, moose, elk, deer, migrant and resident bird species, and native trout species, most notably cutthroat trout.

Population growth, however, is placing great demands on many of Montana's waters, and increases the potential for degradation of their clean and clear character. The Gallatin Blue Water Task Force was established in the spring of 2000 as a volunteer water quality monitoring group. Since that time, the Task Force has collected monthly water quality information at seven locations along the Upper Gallatin River and two of its tributaries near the ski resort town of Big Sky, Montana. Two monitoring sites (Park Boundary and Dudley Creek) were chosen as reference sites because human impacts to water quality should be minimal there. The other sites were chosen to measure potential human impacts to water quality in the Big Sky area over a long period of time.

The goals of the Blue Water Task Force are to collect rigorous water quality information every month for the Upper Gallatin River and to provide educational information to the public. The impetus for starting the program was concern about the lack of baseline water quality information and the potential for population growth to impact local water quality. Citizen volunteers, trained by the Blue Water Task Force, collect water quality information the second Saturday of every month. Data collected by the Task Force meet quality controls specified by the Montana Department of Environmental Quality. Equipment used in the field is calibrated before each collection day, and EPA-approved procedures and proper standards and controls are used for all laboratory analyses. Information collected each month by Task Force volunteers represents a snapshot of the river water quality at the time the sample was collected. Current sampling protocols are not designed to record daily events that may affect water quality but rather long-term trends in water quality over time.

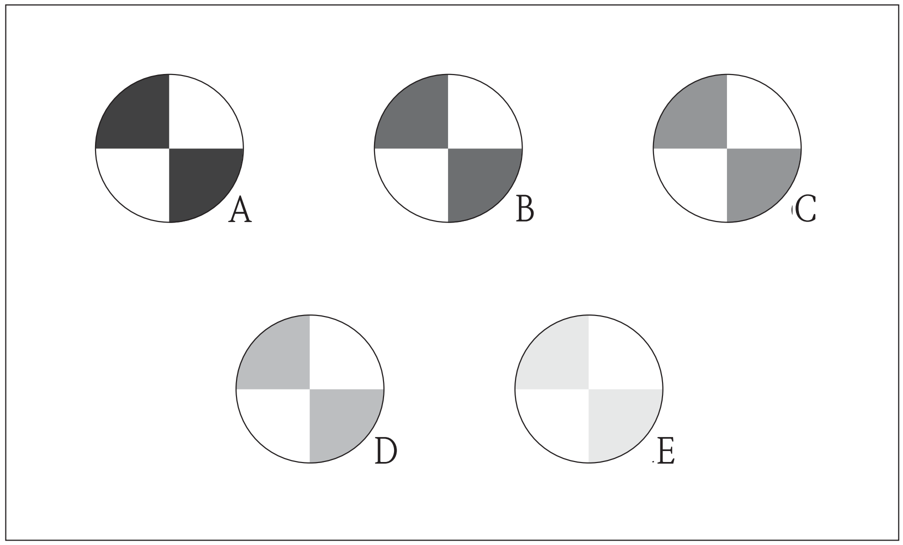
Turbidity Test

1. Fill the test tube or glass with the sample. Continually shake or swirl the container to ensure the sediment stays suspended.

2. Place the test tube/glass over each circle, starting with (A). Look down through the test tube/glass. If you can distinguish between the dark and light sections, move to the next circle (B).

3. The first circle where you cannot distinguish between the dark and light sections is your turbidity reading.

4. If you can distinguish between the dark and light sections in all of the circles, then you have mostly clear water with little turbidity.

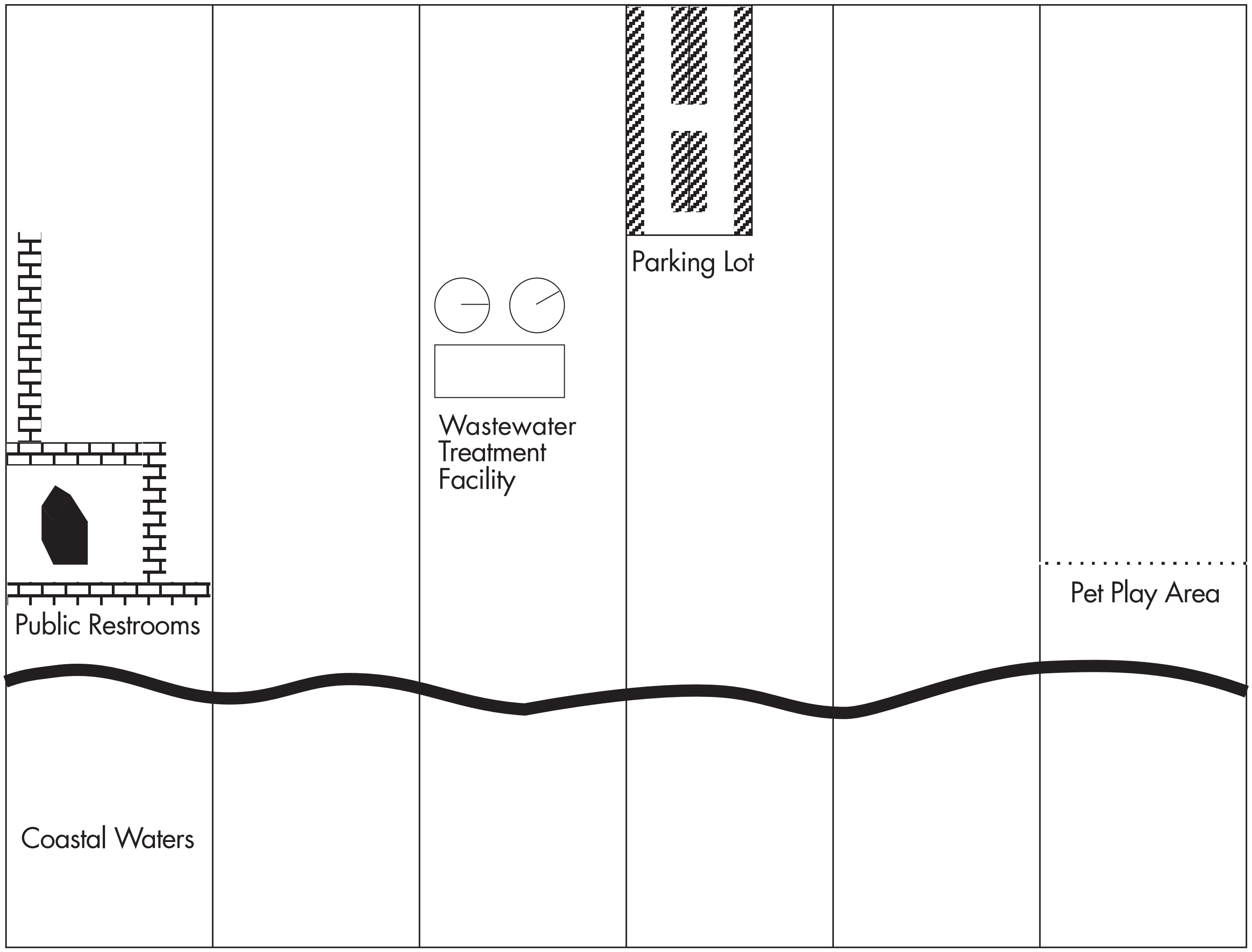


A–Stressful for some fish due to lack of food production
B–Aquatic insect production slows
C–Algae and zooplankton production drops
D–Less light reaches plants, photosynthesis slows
E–Little effect on aquatic plants and animals

Data Sheet for Turbidity Test

Water Sample 1: Letter: Interpretation:
Water Sample 2: Letter: Interpretation:
Water Sample 3: Letter: Interpretation:

Beachfront Properties



Water Contaminants Worksheet

Pollutant	Specific Contaminant	Possible Environmental and Human Health Impacts
Pet Waste	• Nitrate • Phosphate • Coliform bacteria	Algal blooms–dissolved oxygen depletion Algal blooms–dissolved oxygen depletion, *Pfiesteria* Human illness (watery diarrhea, fever, and dehydration)
Sediment	• Turbidity • Phosphate • Coliform bacteria	Blocks sunlight, kills submerged vegetation Algal blooms, dissolved oxygen depletion Human illness (watery diarrhea, fever, and dehydration)
Sewage	• Nitrate • Coliform bacteria	Algal blooms, dissolved oxygen depletion Human illness (watery diarrhea, fever, and dehydration)
Litter	• Coliform bacteria	Human illness (watery diarrhea, fever, and dehydration)
Parking Lot Runoff	• Petroleum products (benzene, toluene, organic lead compounds.)	Human illness (fever, chills, vomiting)
Fertilizers	• Nitrate • Phosphate	Algal blooms, dissolved oxygen depletion Algal blooms: human illness (respiratory illness)
Pesticides	• Chlorinated hydrocarbons, rhothane (DDD), lindane (HCH's), Atrazine	Human illness (headaches, dizziness, respiratory problems) Animal illness (muscle tremors, convulsions, tetanus)
Air Pollution	• Acid rain (sulfate aerosols, nitrogen oxides, copper, nickel, zinc) • Sulfur dioxide	Human illness (inherited heart defects, respiratory diseases, gastrointestinal disorders, skin and eye diseases, asthma, bronchitis, lung inflammation–asthma and emphysema) Acidifies waters (lakes, rivers, streams)
Boat Pollution	• Sewage waste (bacteria) • Nutrient loading • Litter • Oil spills	Human illness (watery diarrhea, fever, dehydration, dizziness, muscle aches, vomiting) *Pfiesteria piscicida* outbreaks; red-tide algal blooms Animal strangulation (can block digestive system when ingested) Human illness (cancer, sterility, brain dysfunction, fever, chills, ear discharge, vomiting)
Waterfowl	• Coliform bacteria	Human illness (watery diarrhea, fever, and dehydration)

Camping Data Sheet

Part I

An active person needs two thirds of an ounce of water per day per pound of body weight. Calculate the amount of water that a fictitious group of campers will need per day by completing the chart below using the following equations:

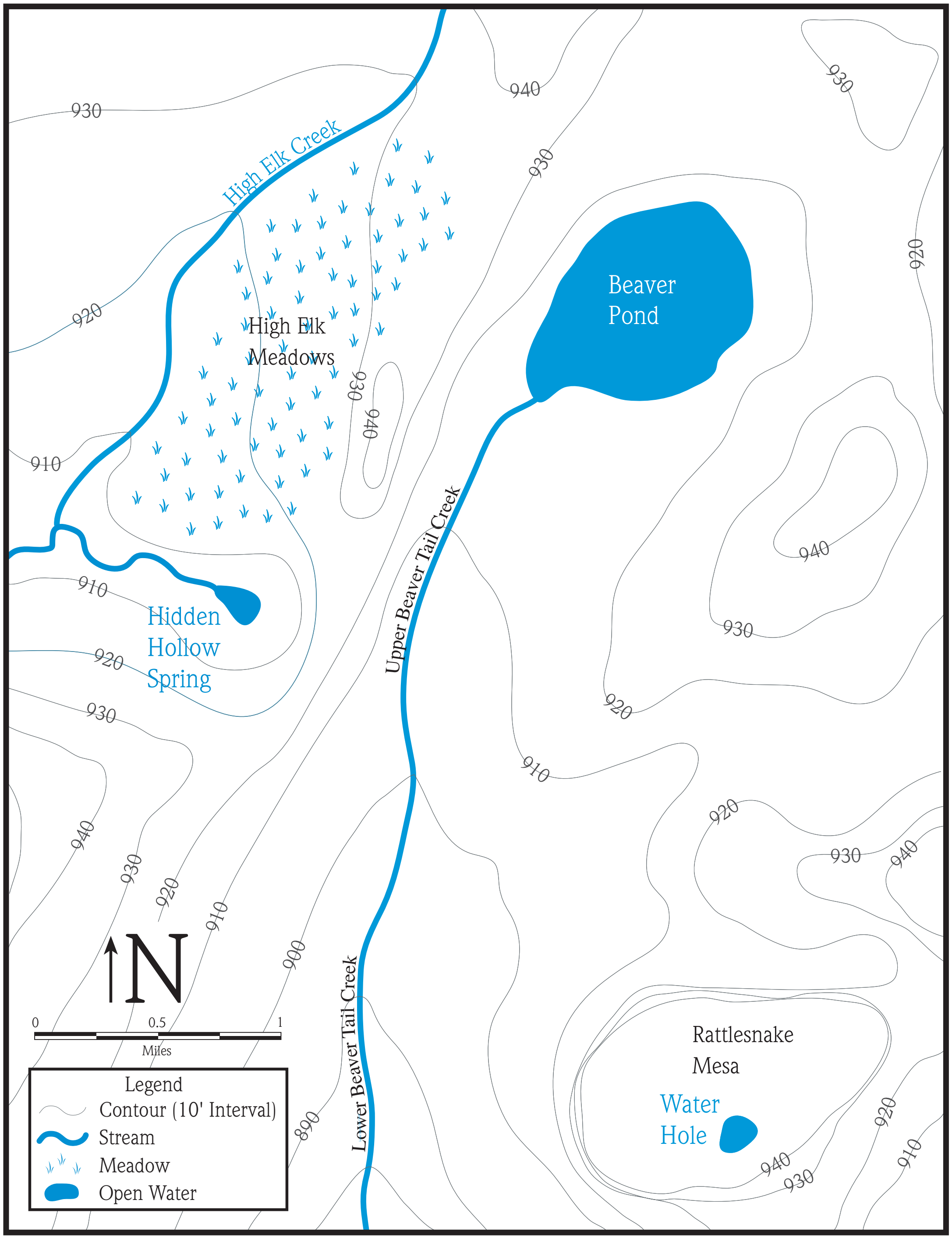
1. (Body weight in pounds) X (0.67 oz.) = __oz. of water per day
2. Convert to liters: 1 fluid ounce = 30 ml or 0.03 liters; therefore
(__ oz. of water per day) X (0.03 liters) = __ liters of water per day

Body Weight x (0.67) = ounces per day x 0.03 liters = liters per day

Camper 1	100 lbs. x	(0.67) =	________ ounces p/day	x (0.03) =	_____ liters p/day
Camper 2	118 lbs. x	(0.67) =	________ ounces p/day	x (0.03) =	_____ liters p/day
Camper 3	120 lbs. x	(0.67) =	________ ounces p/day	x (0.03) =	_____ liters p/day
Camper 4	107 lbs. x	(0.67) =	________ ounces p/day	x (0.03) =	_____ liters p/day
Camper 5	115 lbs. x	(0.67) =	________ ounces p/day	x (0.03) =	_____ liters p/day

Total liters per day needed for entire group: __________ liters per day

Campsite Map Student Copy Page



Situation Cards

Camping Location: Rattlesnake Mesa
Shelter Type: tent; 2 members slept under the stars
Water Source: water hole
Evening Meal: spaghetti, brownies, lemonade from powdered mix
- Saw a rattlesnake and other wildlife visit the water hole
- Great views of the entire area, cold clear night under the stars, good star gazing

Camping Location: Beaver Pond
Shelter Type: lean-to
Water Source: pond
Evening Meal: stew, rolls, peanut butter cookies, water
- Saw wildlife in meadow, saw beavers in the pond
- One member fell into the beaver pond while crossing the dam

Camping Location: High Elk Creek
Shelter Type: tents
Water Source: creek
Evening Meal: hot dogs, chili, s'mores, bottled sports drink which they carried in
- Saw an eagle; viewed wildlife in the meadow
- briefly rained on group, fast-moving creek was soothing for sleep
- Flaming marshmallow caught tent on fire briefly

Camping Location: Beaver Tail Stream, lower
Shelter Type: lean-to
Water Source: carried in all the water they needed
Evening Meal: burritos, tortilla chips, apple crisp, hot chocolate
- Heard unidentified thrashing in the underbrush near camp
- Caught fish in the swift stream; several members fell into the water because of slippery rocks
- Found plenty of wood to build lean-to, drank lots of hot chocolate to keep warm

Camping Location: Hidden Hollow
Shelter Type: tents
Water Source: spring
Evening Meal: pita pocket pizzas, cake, iced tea
- Enjoyed the fresh spring water, bubbling up from the ground
- Saw wildlife and lots of birds
- Burned dinner; tent fell down when group member tripped over its strings

Camping Location: Beaver Tail Stream, upper
Shelter Type: lean-to
Water Source: carried in all the water they needed
Evening Meal: chicken, baked potatoes, chocolate chip cookies, packaged fruit drinks
- Went wading in the stream looking for unique rocks, lean-to fell down during the night
- Saw deer along the stream, leftover food was stolen by raccoons
- Saw a fox drinking from the stream early the next morning

Risk Assessment Worksheet

The Environmental Protection Agency's Risk Assessment Process

Hazard Identification
What health problems are caused by the pollutant?

Exposure Assessment
How does the pollutant move through the environment? How many people are exposed?

Dose-Response Assessment
What are the health problems at different exposures?

Risk Characterization
What is the extra risk of health problems in the exposed population?

1. **Hazard Identification:** After hearing the scenario, why might you think MTBE is a potential hazard? List several reasons.

2. **Exposure Assessment:** Briefly summarize the Exposure Assessment data from *What Is the Risk?*
   Geologic Survey:

   Ecological Site Survey:

   Properties of MTBE:

   Surface Soil Sampling:

   Surface Water Sampling:

   Ground Water Sampling:

3. **Dose-Response Assessment:** Briefly summarize the Dose-Response data from *What Is the Risk?*
Cancer effects:

Non-cancer toxicity:

Taste and odor:

4. **Risk Characterization:** Hazard Identification: Would you consider MTBE a hazard? Why or why not?

Exposure Assessment: Will MTBE move through the environment? Will humans be exposed to MTBE if it does move through the environment?

Dose-Response Assessment: Are there health problems associated with MTBE?

Is there other information not provided that you feel is relevant to characterizing this risk? Based on the data provided, as well as any other information or concerns you may have, what course of action would you suggest for the following organizations?

Wildlife manager of this region:

Municipal water treatment plant manager:

Environmental Protection Agency board for establishing primary drinking water standards:

Environmental Protection Agency board for establishing secondary drinking water standards:

Local residents:

What Is the Risk? Worksheet

The municipal water supply in your city comes from both surface water and ground water (water that is naturally stored underground). Water is pulled directly from the river to the water treatment plant. One well (Town Well 1) is used to pump the water from the ground to the water treatment plant. The well is 45 feet deep. The river, the well and the water treatment plant are located just outside of town. The land surrounding the treatment plant belongs to the state and is unoccupied.

The closest commercial property is a gas station. The pump manager at the gas station noticed profits had been slowly decreasing for several months. She was puzzled since the population was growing in the area and business had been steadily increasing. After serious investigation, she found that they were not selling as much gas as they were purchasing. From this, she concluded that their storage tank was leaking. The storage tank is 35 feet below ground. She reported this information to the Department of Environmental Quality (DEQ).

The DEQ suspected a connection between this information and the increased number of calls from local residents complaining about the strange taste and odor of their drinking water. When the DEQ ordered that the drinking water be tested small amounts of MTBE (methyl tertiary butyl ether) were found. Then, a full-scale risk assessment began.

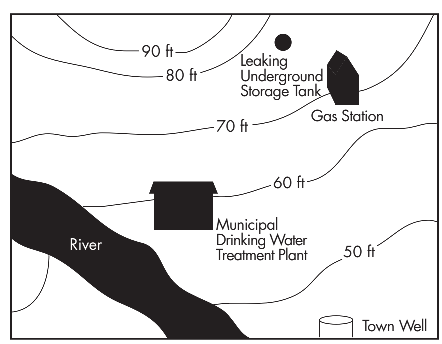
Information supplied by local toxicologists, geologists, concerned citizens, and others has been given to you. You must analyze the information and answer the associated questions on the *Risk Assessment Worksheet.*

I. Exposure Assessment

1. **Geological Survey:** An investigation of the local geology indicates that glacial till underlies most of the site, grading to a silty composition on the banks of the river. There is an impermeable clay layer about 15 feet below ground level that prevents water from passing through this layer. The water table, or the upper surface of the ground water, begins at 30 feet below ground level.

   Local ground water modeling indicates that ground water follows the surface topography, flowing downhill from the north side of the site toward the river. Water moves quickly and easily through glacial till because of its large pore spaces (spaces in-between rocks).

   Mark with an arrow on the picture the direction in which ground water moves.



2. **Ecological Site Survey:** The area surrounding the ground water treatment plant and the gas station is covered with native vegetation—grasses, wildflowers, and trees. No threatened or endangered species live here. In fact, very few animals inhabit the area.

   The river teems with insects and invertebrates, which serve as an excellent food source for birds. Several trout were spotted from the banks, indicating the water temperature is cool. A rapid bioassessment of macroinvertebrate populations determined the river is in excellent condition.

   What findings can you determine about the ecological health of the area?

3. **Properties of MTBE:**
Chemical formula: $C_5H_{12}O$
Boiling point: 55.2 °C
Solubility: 4.8 g/100 g of water This is highly soluble, meaning it dissolves easily in water and will move at the same rate as the ground water. Because of it high solubility, it also tends to be difficult to remove from water

Volatility: extremely volatile, it evaporates easily

Fat solubility: very low, does not accumulate in soils, sediments, and organisms—tends to stay in water or air

Eco-toxicology value: 34,000 μg/l (ppb)—below which there is no expected adverse health effect to any animal species

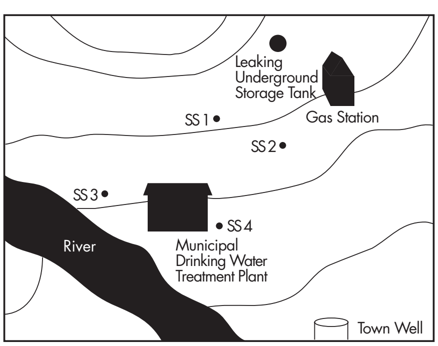
Human Taste and Odor Threshold: 40 μg/l (ppb) below which humans cannot detect the presence of MTBE

Which of these properties might be helpful when assessing risks associated with MTBE? Does any of this information help you determine where in the environment you should focus your investigation? Based on this information, should you look at ground water samples, soil samples, surface water samples?

If humans cannot detect MTBE below about 40 μg/l (ppb), how might this information be useful in establishing a secondary standard for taste and odor?

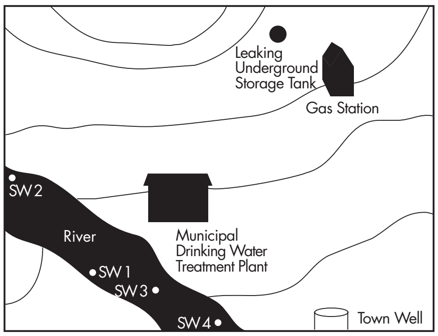
4. **Surface Soil Sampling:** Soil samples were collected from four sites between the gas station and the municipal water treatment plant. The top five inches of soil were collected from each site, and analyzed for MTBE contamination. The map indicates the site locations.

Based on this data, should the DEQ be concerned about the soil around the gas station or the ground water treatment plant? Should they be concerned about wildlife and humans that work around these sites?



MTBE concentration in Surface Soil Samples (μg/l or ppb)			
SS 1	SS 2	SS 3	SS 4
None detected	None detected	None detected	None detected

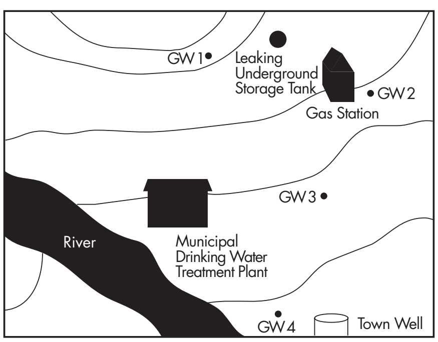
5. **Surface Water Sampling**: Water samples were collected from four sites within the river. Three were taken from near the banks, and one from the middle of the river. The samples from the banks were collected from the surface, while the sample from the middle of the river was collected between the surface and the riverbed. Each sample was analyzed for MTBE contamination. The map indicates the site locations.



MTBE Concentration in Surface Water Samples (μg/l or ppb)			
SW 1	SW 2	SW 3	SW 4
None detected	None detected	None detected	None detected

Based on this data, should the water treatment plant be concerned about using the river as a source for drinking water? Should you be concerned about aquatic organisms and wildlife that rely on the river? Why might contaminated ground water from this site not contaminate the river? Hint: think about the geology.

6. **Ground Water Sampling**: Four temporary sampling wells were dug to the depth of the Town Well 1, which is 45 feet. All of these wells were dug down gradient (which in water terms means downhill) from the leaking underground storage tank to determine if it was the source of contamination in the drinking water. Each sample was analyzed for MTBE contamination. The map indicates the well locations.



MTBE Concentration in Ground Water Wells (μg/l or ppb)			
GW 1	GW 2	GW 3	GW 4
None detected	1,500	800	75

Do you think the amount of MTBE in ground water Wells 3 and 4 will be increasing or decreasing in the future? Should the municipal water treatment plant be concerned about their ground water source?

II. Dose-Response Assessment

Dose-response studies try to link the quantity of a contaminant to its associated health risks. Because dose-response data are not yet available for oral ingestion of MTBE, the EPA has converted inhalation data to oral ingestion data. This process potentially introduces a high degree of error. Though scientists are studying the direct effects of MTBE contaminated drinking water; results are not available at this time. Therefore, base decisions on current data.

1. **Cancer effects:** The current data suggest that high doses (8,000,000 ppb) of MTBE have a potential to cause cancer in humans. Data is currently unavailable on the potential for low doses of MTBE to cause cancer.

2. **Non-cancer toxicity:** Current data suggest that high doses (8,000,000 ppb) of MTBE pose a health hazard to humans. Data is currently unavailable on the potential for low doses of MTBE to pose a health hazard.

3. **Taste and odor:** While human sensitivity to taste and odor varies greatly, current data suggest that most humans cannot smell or taste MTBE in water at concentrations between 20 and 40 micrograms per liter (µg/l) or parts per billion (ppb).

Drinking Water Standards I

Contaminant (mg/L)[2]	**MCLG[1]**	**MCL or TT[1] (mg/L)[2] MCL**	**Potential health effects from exposure above the water**	**Common sources of contaminant in drinking water**
Total Coliforms (including fecal coliform and *E. coli*)	Zero	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5].	Coliforms are naturally present in the environment; as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.
Turbidity	N/a	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g. whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing microorganisms such as viruses, parasites, and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff
Barium	2	2	Increase in blood pressure.	Discharge of drilling wastes discharge from metal refineries; erosion of natural deposits.
Cadmium	0.005	0.005	Kidney damage.	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints.
Chromium (total)	0.1	0.1	Allergic dermatitis.	Discharge from steel and pulp mills; erosion of natural deposits.
Copper	1.3	TT[8]; Action Level=1.3	Short term exposure: Gastrointestinal distress Long term exposure: Liver or kidney damage People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level.	Corrosion of household plumbing systems; erosion of natural deposits.

Drinking Water Standards II

Contaminant (mg/L)[2]	MCLG[1]	MCL or TT[1] (mg/L)[2] MCL	Potential health effects from exposure above the water	Common sources of contaminant in drinking
Cyanide (as free cyanide)	0.2	0.2	Nerve damage or thyroid problems.	Discharge from steel/metal factories; discharge from plastic and fertilizer factories.
Fluoride	4.0	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth.	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories.
Lead	Zero Level= 1.015	TT[8]; Action	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities. Adults: Kidney problems; high blood pressure.	Corrosion of household plumbing systems; erosion of natural deposits.
Mercury (inorganic)	0.002	0.002	Kidney damage.	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands.
Nitrate (measured as Nitrogen)	10	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits.
Nitrite (measured as Nitrogen)	1	1	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits.
Selenium	0.05	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems.	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines.

Drinking Water Standards III

1. Definitions:
    - Maximum Contaminant Level Goal (MCLG)- The level of a contaminant in drinking water below which there is not known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
    - Maximum Contaminant Level (MCL)- The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
    - Treatment Technique (TT)- A required process intended to reduce the level of a contaminant in drinking water.
2. Units are in milligrams per liter (mg/L) unless other wise noted. Milligrams per liter are equivalent to parts per million (ppm).
3. EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that turbidity (cloudiness of water) will at no time go above 5 nephelolometric turbidity units (NTU). Systems that filter must ensure that the turbidity goes no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.
4. No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E.coli* if two consecutive TC-positive samples, and one is also positive for *E.coli* fecal coliforms, system has an acute MCL violation.
5. Fecal coliform and *E.coli* bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, head aches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.
6. Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

Common Waterborne Diseases and Symptom Cards

Typhoid fever–caused by ***Salmonella typhi*** **bacteria.**
Case background:

1.

Symptoms occurred ten days after attending a family camp
Discovered that camp's sewage system was faulty and chlorinator was not functioning
Family reunion had used same camp the previous week; two people who attended had recently recovered from typhoid fever
Began feeling lethargic with general aches and pains
Malaise (general weakness and discomfort) and anorexia–loss of appetite
Developed high fever, became delirious
Tender abdomen with rose-colored spots on skin

Legionnaire's disease–caused by ***Legionella pneumophilia*** **bacteria.**
Case background:

2.

Chain smoker living in warm climate
Lives in a home that is constantly air-conditioned during summer months
Sudden onset of fever that progressed to a high fever with shaking chills
Developed a cough and excessively rapid breathing
Pain in chest; lungs have rattling sound when breathing
General, diffuse muscular pain and tenderness
Intense headache and mental confusion

Cholera–caused by ***Vibrio cholerae*** **bacteria.**
Case background:

3.

Recently returned from Bangladesh
Symptom occurred two days after eating fruit thoroughly washed at outdoor pump
Family members have begun coming down with the same symptoms
Severe dehydration
Painless diarrhea, vomiting
Severe muscular cramps in arms, legs, hands and feet
Eyes and cheeks appear sunken; hands have wrinkled appearance

Amebiasis–caused by ***Entamoeba histolytica,*** **a protozoan.**
Case background:

4.

Returned from Thailand two weeks ago
Drank unbottled water
Feverish
General abdominal discomfort and tenderness, especially on lower right side
Dysentery
Tires easily, mental dullness
Moderate weight loss

Common Waterborne Diseases and Symptom Cards

Enterotoxigenic *E. coli gastroenteritis*–**caused by** *E. coli* **bacteria.**
Case background:

5.	Just returned from visiting friends in Mexico
	Symptoms began 12 hours after drinking several swallows of water from a bucket pulled from a well
	Experiencing dehydration caused by diarrhea
	General, diffuse muscular pain and tenderness
	Low-grade fever
	Nausea, vomiting
	Abdominal cramps

Giardiasis–caused by the *Giardia lamblia* **protozoan.**
Case background:

6.	Symptoms occurred two weeks after backpacking trip
	Filled water bottle with clear, fresh-tasting water from a stream below a beaver dam
	Abdominal cramps
	Intermittent dysentery (which is greasy and odorous)
	Excessive intestinal gas
	Malaise–general weakness and discomfort
	Weight loss

Salmonellosis–caused by a species of *Salmonella* **bacteria.**
Case background:

7.	Lives on a ranch that raises cattle and chickens
	Symptoms occurred 10 hours after drinking from pump outside of barn (ground water may have been contaminated by surface water in the pasture after heavy rain)
	Malaise–general weakness and discomfort
	Fever
	Dysentery
	Abdominal cramps
	Nausea and vomiting

Shigellosis–caused by a species of *Shigella* **bacteria.**
Case background:

8.	Four years old
	Symptoms began 15 hours after bobbing for apples in pre-school class
	Severe abdominal cramps
	Frequent, painful dysentery
	Blood and mucus in stool
	High fever, chills
	Dehydration

Common Waterborne Diseases and Symptom Cards

Hepatitis A.–caused by *Hepatitis A* **virus.**
Case background:

9.

Visited favorite beach and swam with friends
Malaise–general weakness and discomfort
Anorexia–loss of appetite
Fever
Nausea, mild diarrhea
Jaundice–yellowing of skin and whites of eyes
Sick for a week

Control Card. (Individual has no waterborne illness.)
Case background:

10.

Lives in an apartment in the city
Chain smoker living in a warm climate
Drinks tap water
Pain in chest; lungs have rattling sound when breathing
Visited favorite beach and swam with friends
Recently visited an alligator farm
Eats lots of fresh seafood

Cryptosporidiosis–caused by *Cryptosporidium.*
Case background:

11.

Four years old
Attends a daycare center five days a week
Diarrhea
Nausea and vomiting
Fever
Sucks thumb
Recently swam in a local pond

Control Card. (Individual has no waterborne illness.)
Case background:

12.

Lives on a ranch that raises cattle and chicken
Just returned from visiting friends in Mexico
Lives in a home that is constantly air-conditioned during summer months
Is tired in the late afternoon
Often conducts pack trips in the mountains
Works 14 hours a day, usually seven days a week
Drinks eight glasses of water per day

Disease Descriptions

Typhoid fever–caused by *Salmonella typhi* **bacteria.**
Now uncommon in the U.S., this is usually acquired during foreign travel. During the first half of this century it was the most commonly reported cause of waterborne disease in the U.S. It can be acquired by contact with contaminated water, swimming, etc. In 1907, Mary Mallon, nicknamed "Typhoid Mary," was identified as a carrier of the disease. She transmitted the disease while working as a cook in restaurants and private homes in New York City. She escaped authorities for eight years, but was finally apprehended in 1915. She infected some 50 people, three of whom died. In 1973, a major outbreak of typhoid fever affected 225 people in a migrant labor camp in Dade County, Florida. The well that supplied water to the camp was contaminated by surface water. Symptoms include tender abdomen, pink spots on skin, high fever. Those infected may also feel delirious and weak.

Legionnaire's disease–caused by *Legionella pneumophilia* **bacteria.**
Found naturally in water environments; bacteria often colonize artificial water systems such as air conditioners and hot water heaters, and can be inhaled with aerosols produced by such systems. Smoking and lung disease increase susceptibility to disease. A person infected may experience rapid breathing, heavy cough, headache, and shaking chills. They may also feel as if their lungs rattle when they breathe.

Cholera–caused by *Vibrio cholerae* **bacteria.**
Extremely contagious; if untreated, dehydration can lead to death. Cholera originated in Europe and was spread to the United States by transatlantic liners through New Orleans. It reached California through the Forty-niners in their quest for gold. Recent outbreaks of cholera have occurred throughout the United States. Along the Gulf Coast, water and seafood were identified as contributing to the outbreaks. In Louisiana, undercooked crab was the culprit. In 1981, people in Texas were infected after eating cooked rice that had been washed with contaminated water. Cholera causes severe muscle cramps in the extremities of the body, dehydration, diarrhea and the infected person's eyes and cheeks may appear sunken in.

Amebiasis–caused by *Entamoeba histolytica,* **a protozoan.**
Usually occurs in tropical areas where crowding and poor sanitation exist. Waterborne outbreaks are now rare in the United States. The *Entamoeba histolytica* protozoan will cause abdominal tenderness and discomfort, dysentery, and fever.

Enterotoxigenic *E. coli gastroenteritis*–**caused by** *E. coli* **bacteria.**
Leading cause of infant mortality worldwide. Visitors to Latin American countries who partake of the food and water occasionally come down with "traveler's diarrhea," also known as "turista" or "Montezuma's Revenge." A large outbreak of this disease occurred in 1975 in Crater Lake National Park, Oregon. About 2,000 park visitors and 200 park employees became ill after consuming water contaminated by sewage. Abdominal cramping, nausea, and vomiting are all tell-tale symptoms of the infection.

Giardiasis–caused by the *Giardia lamblia* **protozoan.**
Sickness results with only a low dose of the protozoan; it is the most commonly reported cause of waterborne outbreaks. The *giardia* protozoan is killed by boiling water for at least five minutes or is removed by passing water through a filter whose pore size is 0.2 microns or smaller. Infected persons will experience weight loss, intestinal gas, and intermittent dysentery.

Disease Descriptions

Salmonellosis–caused by a species of *Salmonella* bacteria.
Carried by humans and many animals; wastes from both can transmit the organism to water or food. The largest waterborne salmonella outbreak reported in the United States was in Riverside, California, in 1965 and affected over 16,000 people. Salmonellosis causes fever, nausea, vomiting, and dysentery.

Shigellosis–caused by a species of *Shigella* bacteria.
Most infection is seen in children 1-10 years old; a very low dose can cause illness. Waterborne transmission is responsible for a majority of the outbreaks. Children infected may experience blood and mucus in stools, frequent and heavy dysentery, and high fever.

Hepatitis A.–caused by *Hepatitis A* virus.
It is the third most common cause of waterborne disease in U.S. The term "hepatitis" refers to inflammation of the liver. Hepatitis A causes jaundice (a yellowing of the skin and whites of the eyes), nausea and fever, and lasts approximately one week.

Cryptosporidiosis–caused by *Cryptosporidium.*
This was first identified as a cause of diarrhea in people in 1976. It can be transmitted through contact with animals (particularly cattle and sheep), other humans (especially in daycare centers), and contaminated water supplies. Infection will cause diarrhea, fever, nausea, and vomiting.

Waterborne Disease Worksheet

Now that you have identified others with an illness similar to yours, work as a group to research your disease and answer the following questions:

Disease Name: ______________________________

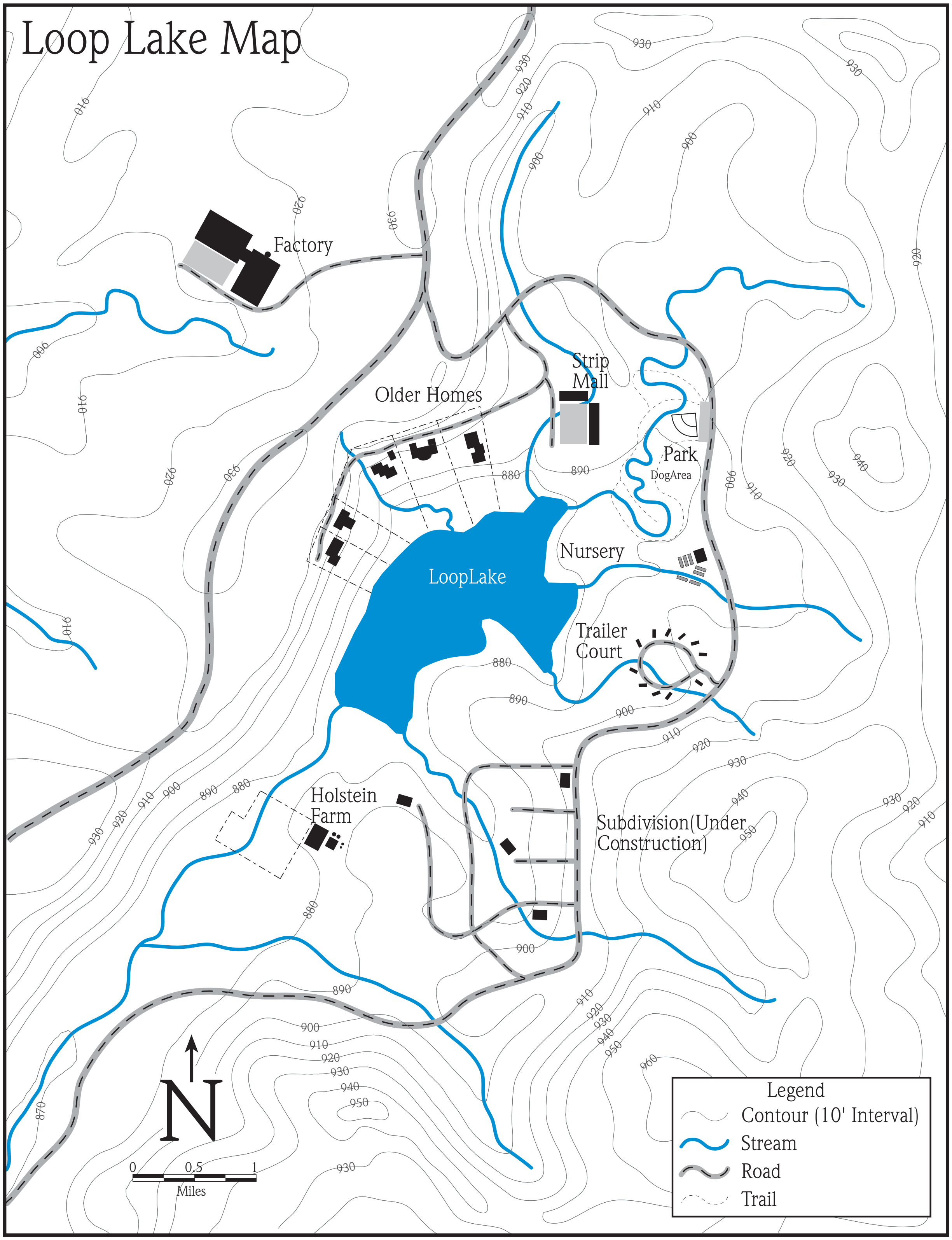
1. How did you contract the disease?

2. Where does your disease occur in the U.S. and the world? Plot the disease on a world map.

3. How is your disease transmitted to others?

4. How can the spread of your disease be prevented?

5. List conditions that might help your disease spread (e.g., inadequate water treatment systems, concentrated population, political upheaval that forces large migrations of people, organisms such as beavers or snails, etc.).


Loop Lake Map
Factory
Older Homes
Strip Mall
Park
DogArea
Nursery
LoopLake
Trailer Court
Holstein Farm
Subdivision(Under Construction)
N
0
0.5
1
Miles
Legend
Contour (10' Interval)
Stream
Road
Trail

Loop Lake Worksheet

Part I

Map Reading

1. Locate the contour lines on the map. These lines indicate the elevation of the land at a location on the map. Since there are ten feet between each contour line, comparisons with other elevations can be made. Place a circle on the highest and lowest points on the map.
2. Locate the streams on the map. Streams always flow from the highest to the lowest elevations. How many streams are there? _________ Locate the stream that flows through the subdivision and mark its highest and lowest elevations with an X. What is the elevation of the highest point on this stream? How many feet in elevation does this stream drop between its highest and lowest points?
3. Place a Y on the highest points of the streams that flow into Loop Lake.
   a. Place a Z on the highest points *above the streams* that flow into Loop Lake
   b. Following the highest elevations between these points, connect these Zs with lines.
   c. This outline encompasses all of the land area that drains into Loop Lake. What is the name for an area that is drained by streams and flows to a central location? ________________
4. One stream serves as the outlet stream for Loop Lake. Locate it and name the business that the stream flows through. How did you know that this was the outlet stream for the lake?

____

Part II

1. After hearing the story of the fish kill in Loop Lake, write whether you think the factory is to blame. Why or why not?

Part III

1. After analyzing the water quality data, write your predictions of the causes of the algal bloom and fish kill. Be sure to write your reasons or evidence for your prediction.

Part IV

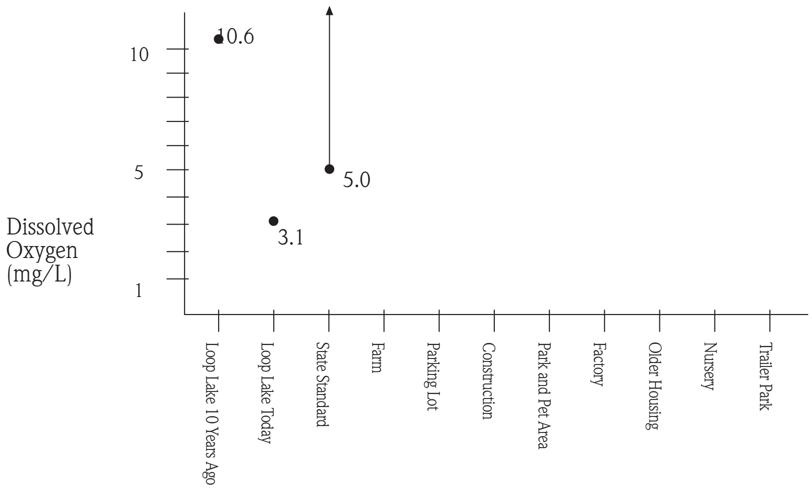
1. How many of the land uses around Loop Lake have fertilizer/nutrient levels that exceed the state standards? __________________ For turbidity? ________________
2. Write an explanation for how the algal blooms and fish kill occurred in Loop Lake:

3. Is the pollution that caused the fish kill in Loop Lake from point sources or nonpoint sources?

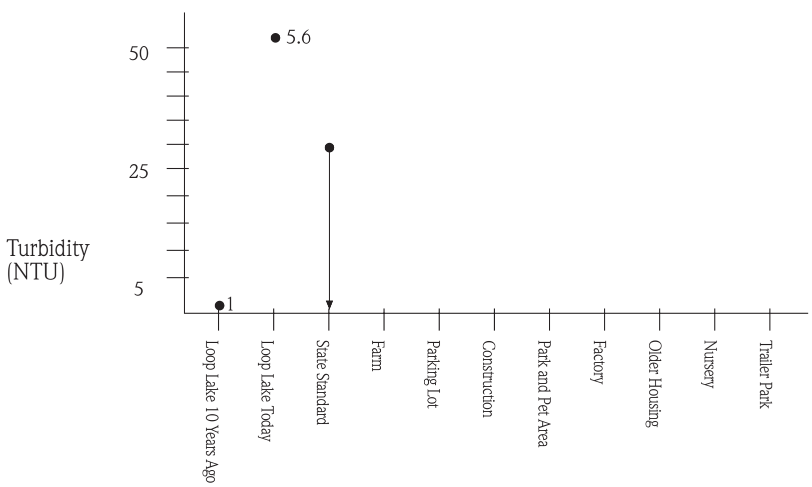
Water Quality Data

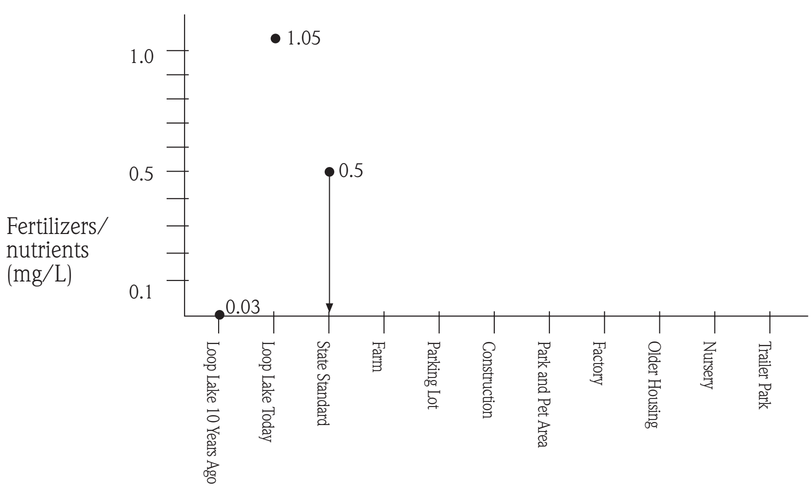
Mr. and Mrs. Holstein's Farm Dissolved Oxygen: 8.7 mg/L Turbidity: 12 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)	**Parking Lot** Dissolved Oxygen: 5.6 mg/L Turbidity: 18 NTU Fertilizers/Nutrients: 0.1 mg/L Temperature: 15° C (59 F)
New Apartments –Construction Dissolved Oxygen: 5.8 mg/L Turbidity: 33 NTU Fertilizers/Nutrients: 0.1 mg/L Temperature: 15° C (59 F)	**Loop Lake Park and Pet Play Area** Dissolved Oxygen: 5.1 mg/L Turbidity: 6 NTU Fertilizers/Nutrients: 0.5 mg/L Temperature: 15° C (59 F)
Factory Dissolved Oxygen: 8.9 mg/L Turbidity: 7 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)	**Older Housing Development** Dissolved Oxygen: 5.2 mg/L Turbidity: 4 NTU Fertilizers/Nutrients: 0.48 mg/L Temperature: 15° C (59 F)
Jack Pine's Nursery Dissolved Oxygen: 5.7 mg/L Turbidity: 10 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)	**Trailer Park** Dissolved Oxygen: 5.9 mg/L Turbidity: 9 NTU Fertilizers/Nutrients: 0.3 mg/L Temperature: 15° C (59 F)

Water Quality Graphs



Note: The arrows represent the range of possible values. For example, "Dissolved oxygen shall not be less than 5.0 mg/L."





Drinking Water Worksheet

1. Cut your 2-liter bottle in half. Place about .5 liters of the source water in the bottom half. Observe the color and smell of the water and record your observations:

2. Aeration: To aerate, pour the water back and forth between the top and bottom halves ten times. End with the water in the bottom half of the bottle. Discuss and record any changes observed:

3. Coagulation: To remove suspended solids, alum is added to encourage coagulation and settling (flocculation) of the particles. Add a teaspoon of alum crystals to the source water. *(Important: Do not to touch the alum! If you do, immediately wash hands or affected areas with soap and water.)* Slowly stir the mixture for five minutes. You should see particles forming clumps (floc). Record changes in the water's appearance:

4. Sedimentation: Floc is allowed to settle out. Let the water rest undisturbed for 20 minutes (begin Step 5 while waiting). Record what is causing the floc to settle. ____________________________ Record observations of the sample every five minutes:
Start: ___________________________________5 mins: ____
10 mins: _______________________________15 mins: ____
20 mins:____

5. Filtration: Removes finer suspended particles. Construct a filter from the top half of your 2-liter bottle as follows:

a. Remove the cap and place a coffee filter over the mouth, securing it with a rubber band. Turn the bottle upside down.
b. Pour one cup (.24 l) of pebbles or aquarium gravel into the bottle. Pour one cup (.24 l) of coarse sand on top of the pebbles. Pour one cup (.24 l) of fine sand on top of the coarse sand.
c. **Slowly** pour several cups of clean tap water through the filter to clean it. Try not to disturb the fine sand layer as you pour.
d. Pour your source water through the sand filter while holding it over a large beaker.
e. Compare your source water now to the source water you started with. Record observable changes:

1. Assess the appearance and smell of your wastewater. Test the pH and check for the presence of oil by placing a drop on brown paper. If oil is present, an oil smear will form around the drop. If oil is not present, no smear will form.

2. Formulate a plan to clean your wastewater. Use any of the available cleaning products provided. Be sure to list a series of steps so that you can later evaluate the effectiveness of each step.

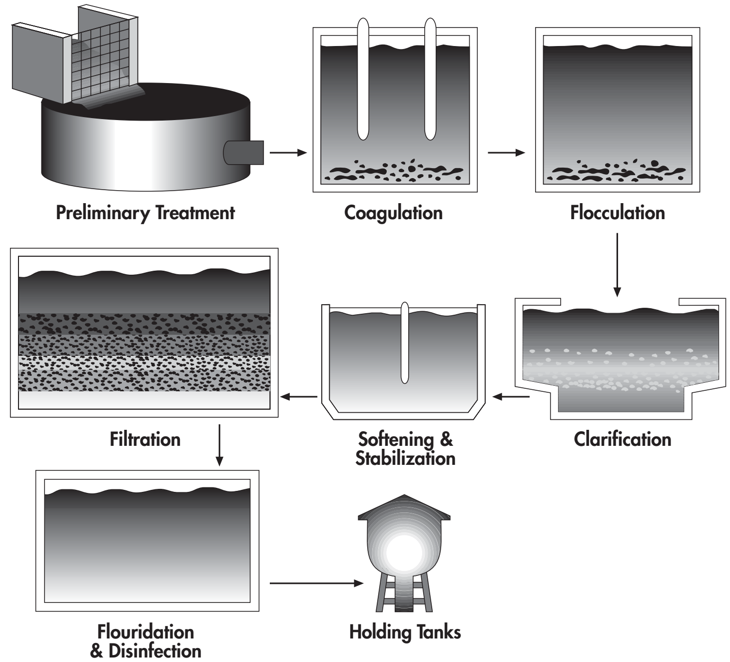
3. Evaluate the effectiveness of each step in your wastewater treatment plan. For example, was there an observable change as a result of each step? Record these changes as you implement your wastewater treatment plan.

4. Assess the appearance and smell of your wastewater. How does the wastewater compare to the observations made in question 1? Be sure to test the pH and for the presence of oil.

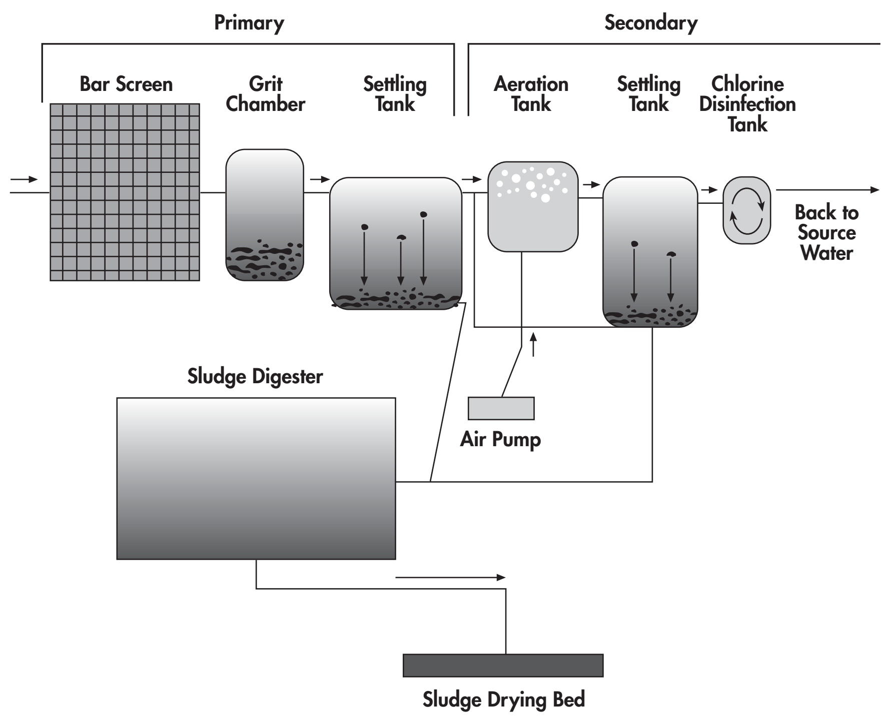
5. Were there some contaminants that were not removed? Could they be removed if you had other equipment or more time?

Wastewater Worksheet

Drinking Water Treatment System



Wastewater Treatment



Macroinvertebrate Identification Chart

Macroinvertebrate	**Looks like…** (draw the invertebrate here)	**Represented by…** (for example beads, coins, etc)
Mayflies (Order *Ephemeroptera*)		
Stoneflies (Order *Plecoptera*)		
Caddisflies (Order *Trichoptera*)		
Dobsonflies (Order *Megaloptera*)		
Midges (Order *Chironomidae*)		
Craneflies (Order *Diptera*)		
Dragonflies (Order *Odonata*)		
Scuds (Order *Amphipoda*)		
Pouch Snails (*Class Gastropoda*)		
Tubifex Worms (Class *Oligochaeta*)		
Leeches (Class *Hirudinea*)		

Macroinvertebrate Data Sheet I

Stream #: ______

Recorded by: ______

Date of Sampling: ______

Percent Composition of Major Groups:

After the macroinvertebrates are sorted, tabulate the number of organisms for each of the major groups listed below and calculate their percent composition. This measure yields the relative abundance of macroinvertebrates within your sample.

$$\text{Percent Composition} = \frac{\text{Number of Organisms in Each Group}}{\text{Total Number of Organisms}}$$

Macroinvertebrates	**Number of Organisms in Each Group**	**Percent Composition**
Mayflies (Order *Ephemeroptera*)		
Stoneflies (Order *Plecoptera*)		
Caddisflies (Order *Trichoptera*)		
Dobsonflies (Order *Megaloptera*)		
Midges (Order *Chironomidae*)		
Craneflies (Order *Diptera*)		
Dragonflies (Order *Odonata*)		
Scuds (Order *Amphipoda*)		
Pouch Snails (Class *Gastropoda*)		
Tubifex Worms (Class *Oligochaeta*)		
Leeches (Class *Hirudinea*)		
Total Number of Organisms		

(Adapted from Mitchell, 1997)

Macroinvertebrate Data Sheet II

Pollution Tolerance Index

1. Place a check next to each macroinvertebrate group present in your sample. For example, whether you found one mayfly or fifty mayflies, place one check next to the mayfly line in Group 1.
2. Complete the chart for all of the macroinvertebrate groups.
3. Calculate the group scores using the multipliers provided.
4. Total all of the group scores for your Total Score.
5. Compare your Total Score with the Water Quality Assessment Chart scores and record the relative water quality rating for your stream sample.

Stream #: ______________________________
Recorded by: ______________________________
Date of Sampling: ______________________________

Group 1 Macroinvertebrates: Very Intolerant	Group 2 Macroinvertebrates: Intolerant	Group 3 Macroinvertebrates: Tolerant	Group 4 Macroinvertebrates: Very Tolerant
_____Stoneflies _____Mayflies _____Caddisflies _____Dobsonflies	_____Dragonflies _____Scuds _____Craneflies	_____Midges _____Leeches	_____Pouch Snails ____Tubifex worms
# of checks = ____ x 4 Group Score=____	# of checks =____ x 3 Group Score=____	# of checks =____ x 2 Group Score=____	# of checks =____ x 1 Group Score=____
Total Score = ________ Your Water Quality Assessment:		Water Quality Assessment Chart: ≥23 Potentially Excellent Water Quality 17-22 Potentially Good Water Quality 11-16 Potentially Fair Water Quality ≤10 Potentially Poor Water Quality	

(Adapted from Mitchell, 1997)

Organism Cards

Pacific Halibut *Hippoglossus stenolepis* Temperature: 3-8°C Salinity: 27.5-33.5 ppt **Saltwater**	**Northern pike** *Esox lucius* Temperature: 10-28°C dissolved oxygen: 7.8-11.3 mg/L pH: 5-9 **Freshwater**	**Flathead catfish** *Pylodictis olivaris* Temperature: 20-32.5°C dissolved oxygen: 7.3-9.1 mg/L pH: 7-9 **Freshwater**
Pacific cod *Gadus macrocephalus* Temperature: 7-8°C Salinity: 12.7-23 ppt **Saltwater**	**Rainbow trout** *Oncorhynchus mykiss* Temperature: 10-24°C dissolved oxygen: 8.4-11.3 mg/L pH: 6.7-8 **Freshwater**	**Microbe** *Sulfolobus acidocaldarins* Temperature: 60-90°C dissolved oxygen: 2.8-4.7 mg/L pH: 2-3 **Hot Springs**
Cutthroat trout *Oncorhynchus clarki clarki* Temperature: 12.7-20°C dissolved oxygen: greater than 6 mg/L pH: 4.5-9 **Freshwater**	**Largemouth bass** *Micropterus salmoides* Temperature: 10-32°C dissolved oxygen:: 7.3-11.3 mg/L pH: 7-9 **Freshwater**	**Microbe** *Pyrolobus fumarii* Temperature: 90-113°C dissolved oxygen: 1.6-2.8mg/L pH: 4-6.5 **Deep Sea Hydrothermal Vents**
Spotted Seatrout *Cynoscion nebulosus* Temperature: 15-27°C Salinity: varies **Saltwater**	**Rock bass** *Ambloplites rupestris* Temperature: 10-30°C dissolved oxygen: 7.6-11.3 mg/L pH: 7.0-9.0 **Freshwater**	**Microbe** *Polaromanas vacuolata* Temperature: 0-10°C dissolved oxygen: 11.3-14.6 mg/L pH: 6-8 **Antarctic Sea Ice**
Brown Trout *Salmo trutta trutta* Temperature: 10-24°C dissolved oxygen: 8.4-11.3 mg/L pH: 6.7-8 **Freshwater**	**Channel catfish** *Ictalurus punctatus* Temperature: 10-32°C dissolved oxygen: 7.0-11.3 mg/L pH: 7.0-9.0 **Freshwater**	**Grayling** *Prototroctes oxyrhynchus* Temperature: 6-18°C pH: 7-7.5 dissolved oxygen: Varies **Freshwater**

Organism Cards

Dungeness crab *Caner magister* Temperature: 8-10°C Salinity: varies **Saltwater**	**Blue marlin** *Makaira nigican* Temperature: 21-27°C Salinity: 35-36 ppt **Saltwater**	**Slimy sculpin** *Cottus cognatus* Temperature: 4-16°C dissolved oxygen: 9.9-13.1 mg/l pH: 6-8 **Freshwater**
Blue crab *Callinectes sapidus* Temperature: 1-34°C Salinity: 3-15 ppt **Saltwater**	**Black sea bass** *Centropristis striata* Temperature: 6-29°C Salinity: 1-36 ppt **Saltwater**	**Redbreast sunfish** *Lepomis auritus* Temperature: 4-22°C dissolved oxygen: 8.7-13.1 mg/l pH: 7.0-7.5 **Freshwater**
White perch *Morone americana* Temperature: 2-32.5°C Salinity: 5-18 ppt **Saltwater**	**Spiny lobster** *Panulirus argus* Temperature: around 20°C Salinity: not below 19 ppt **Saltwater**	**Brook trout** *Salvelinus fontinalis* Temperature: 6-20°C dissolved oxygen: 9.1-12.4 mg/l pH: 6-8 **Freshwater**
Spotted seatrout *Cynoscion nebulosus* Temperature: 15-27°C Salinity: varies **Saltwater**	**American oyster** *Crassostrea virginica* Temperature: 20-30°C Salinity: 20-35 ppt **Saltwater**	**Arctic char** *Salvelinus alpinus* Temperature: 4-16°C dissolved oxygen: unknown **Freshwater**

Answer Key

Water Quality Window **#1** **Freshwater** Temp: 4-22°C DO: 8.5-13.5 mg/l pH: 6-8 • Redbreast sunfish • Slimy sculpin • Brook trout • Grayling • Arctic Char	Water Quality Window **#4** **Saltwater** Temp: 1-34°C Salinity: 3-18 ppt • Blue crab • White perch • Spotted seatrout	Water Quality Window **#7** Extreme Environments Microbe 1: (*Sulfolobus acidocaldarins*) **Hot Springs;** Temp: 60-90°C DO: 2.8-4.7 pH: 2-3 Microbe 2: (*Pyrolobus fumarii)* **Deep Sea Hydrothermal Vents** Temp: 90-113°C DO: 2.8-1.6mg/L pH: 4-6.5 Microbe 3: (*Polaromanas vacuolata*) **Antarctic Sea Ice** Temp: 0-10°C DO: 11.3-14.6mg/L pH: 6-8
Water Quality Window **#2** **Freshwater** Temp: 10-28°C DO: 6.5-11.3 mg/l pH: 5-9 • Brown trout • Cutthroat trout • Rainbow trout • Northern pike	Water Quality Window **#5** **Saltwater** Temp: 6-30°C Salinity: 1-36 ppt • Blue marlin • Black sea bass • Spiny lobster • American oyster • Spotted seatrout	
Water Quality Window **#3** **Freshwater** Temp: 10-32°C DO: 7-12 mg/l pH: 7-9 • Largemouth bass • Rock bass • Channel catfish • Flathead catfish	Water Quality Window **#6** **Saltwater** Temp: 3-10°C Salinity: 7-34 ppt • Pacific cod • Dungeness crab • Pacific Halibut	

Water Quality Windows

Water Quality Window **#1** **Freshwater** Temperature: 4-22°C DO: 8.5-13.5 mg/L pH: 6-8	Water Quality Window **#5** **Saltwater** Temperature: 6-30°C Salinity: 1-36 ppt
Water Quality Window **#2** **Freshwater** Temperature: 10-28°C DO: 6.5-11.3 mg/L pH: 5-9	Water Quality Window **#6** **Saltwater** Temperature: 3-10°C Salinity: 7-34 ppt
Water Quality Window **#3** **Freshwater** Temperature: 10-32°C DO: 7-12 mg/L pH: 7-9	Water Quality Window **#7** **Extreme Environments** (organism does not fit within other windows)
Water Quality Window **#4** **Saltwater** Temperature: 1-34°C Salinity: 3-18 ppt	

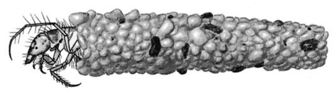
Macroinvertebrate Groups
Caddisfly larva
Mayfly nymph
Stonefly nymph
Dragonfly nymph
Damselfly nymph
Midge larva
Rat-tailed maggot

Intolerant Macroinvertebrates and Hindrances		
ORGANISM	HINDRANCE	RATIONALE FOR HINDRANCE
Caddisfly	Must place both feet in a sack and hop across field, stopping to gasp for breath every five hops.	Caddisflies are intolerant of low oxygen levels.
Stonefly	Must do a push-up every ten steps.	When oxygen levels drop, stoneflies undulate their abdomens to increase the flow of water over their bodies.
Mayfly	Must flap arms and spin in circles when crossing field.	Mayflies often increase oxygen absorption by moving gills.

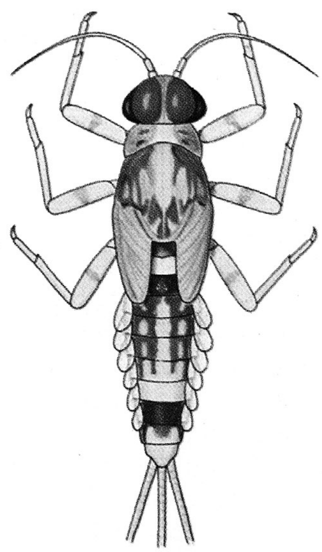
Data Chart

ORGANISM	TOLERANCE	START	ROUND 1	ROUND 2	ROUND 3
Caddisfly larva	Intolerant				
Mayfly nymph	Intolerant				
Stonefly nymph	Intolerant				
Dragonfly nymph	Facultative				
Damselfly nymph	Facultative				
Midge larva	Tolerant				
Rat-tailed Maggot	Tolerant				
TOTAL					

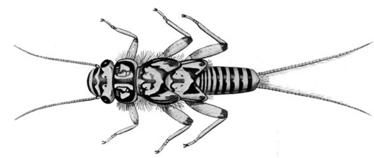
Macroinvertebrate Illustrations



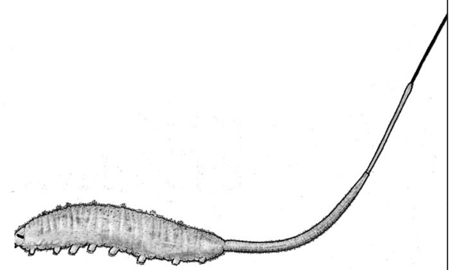
Caddisfly larva



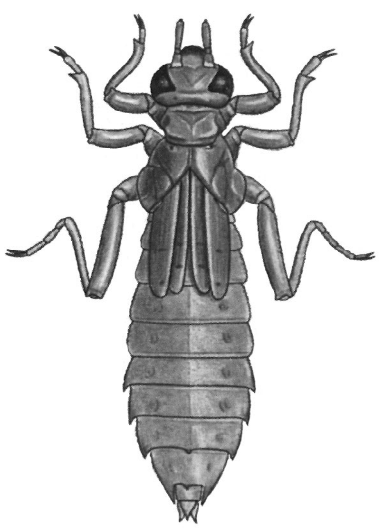
Mayfly nymph



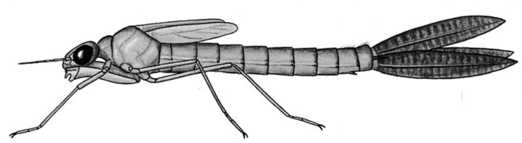
Stonefly nymph



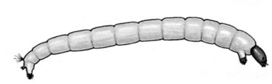
Rat-tailed Maggot



Dragonfly nymph



Damselfly nymph



Midge larva

W. Patrick McCafferty, Aquatic Entomology, 1998: Jones and Bartlett Publishers; Sudbury, MA. www.jbpub.com. Reprinted with permission

Watershed Restoration Worksheet

1. Describe the watershed—its location, length, drainage area, and prominent features.

2. Identify the pollution history of the watershed. Why does the watershed need restoring?

3. List the mission of the watershed RAP—Remedial Action Plan—(plan for restoring the watershed).

4. Who is doing the restoration work in this watershed?

5. List the projects used to restore the watershed.

6. What community activities are aiding restoration efforts in the watershed?

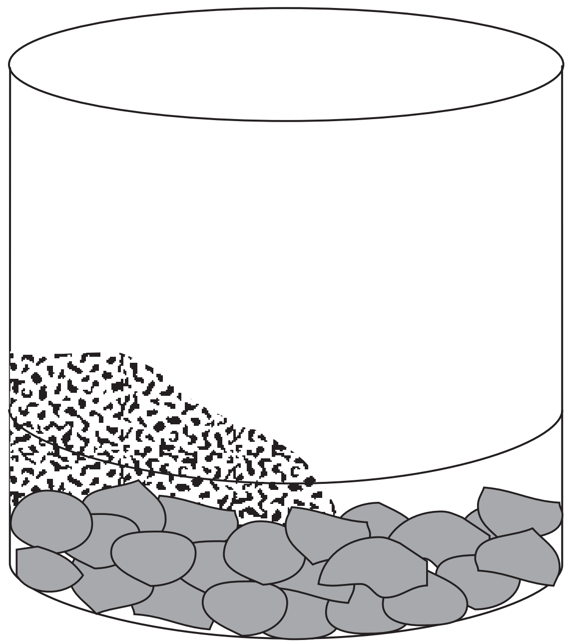
7. List indicators or examples of improved environmental quality in the watershed.

Ground Water Scenarios

Scenario 1: An old underground gas tank on your property is leaking waste into the ground water. 1. Dig a small hole about two inches deep in the sandy side of your ground water model. 2. Place two drops of food coloring in the hole to represent the leaking waste. 3. Re-cover the hole with sand. 4. Later it rains. To simulate this, put water in the paper cup with holes in the bottom. Repeat four times. 5. Answer questions from the Ground Water Worksheet.
Scenario 2: Your neighbor continues to dispose of his used motor oil in his back yard. 1. Place two drops of food coloring on the surface of the sandy side of your model to simulate the oil disposal. 2. Later it rains. To simulate this, put water in the paper cup with holes in the bottom. Repeat four times. 3. Answer questions from the Ground Water Worksheet.
Scenario 3: It has just been revealed that a factory has been discharging water contaminated with hazardous waste into the bay on which you live. The factory is being reprimanded, but it will take time to remove the hazardous waste. 1. Place two drops of food coloring in the lake of your model to simulate hazardous waste in the bay. 2. Later it rains. To simulate this, put water in the paper cup with holes in the bottom. Repeat four times. 3. Answer questions from the Ground Water Worksheet.
Scenario 4: You live in a well-established neighborhood on a lakeshore. You and your neighbor have well-manicured lawns extending almost to the beach. You both fertilize your lawns regularly to maintain their appearance. 1. Place two drops of food coloring on the lakeshore, two inches apart. This represents you and your neighbor fertilizing your lawns. 2. Later it rains. To simulate this, put water in the paper cup with holes in the bottom. Repeat four times. 3. Answer questions from the Ground Water Worksheet.

Ground Water Worksheet

1. Label the following items on the ground water model picture:
   a. water table
   b. saturated zone
   c. unsaturated zone
   d. ground water
   e. surface water



2. After adding the pollution, list the places you can observe it in your model.

3. Pump a little water out of the ground water using your lotion pump, or simulated well. What color was the water? Depending on the type of pollution represented in your scenario, is the water from your well safe to drink now that it contains this pollutant? (NOTE: Do not drink the water!)

4. In a paragraph or illustration, summarize how precipitation can become ground water, and how pollution on the land's surface can also pollute ground water.